

**GEOTECHNICAL INVESTIGATION
SURFACE WATER TRANSMISSION PROGRAM
AIR VALVE AND MANHOLE RECONSTRUCTION
FEDERAL, IH-10, IH-610, MCCARTY & KELLY
HOUSTON, TEXAS
GFS NO. S-0701-02-2; FILE NO. WA10775**

**REPORTED TO
LOCKWOOD, ANDREWS & NEWNAM, INC.
HOUSTON, TEXAS**

by

**Aviles Engineering Corporation
5790 Windfern
Houston, Texas 77041
713-895-7645**

REPORT NO. G105-04

FEBRUARY 2004

GEOTECHNICAL INVESTIGATION
SURFACE WATER TRANSMISSION PROGRAM
AIR VALVE AND MANHOLE RECONSTRUCTION
FEDERAL, IH-10, IH-610, MCCARTY & KELLY
HOUSTON, TEXAS
GFS NO. S-0701-02-2; FILE NO. WA10775

EXECUTIVE SUMMARY	i
1.0 <u>INTRODUCTION</u>	1
1.1 <u>General</u>	1
1.2 <u>Location and Description of Project</u>	1
1.3 <u>Scope of Work</u>	1
2.0 <u>SUBSURFACE INVESTIGATION PROGRAM</u>	2
3.0 <u>LABORATORY TESTING PROGRAM</u>	3
4.0 <u>SUBSURFACE AND SITE CONDITIONS</u>	3
4.1 <u>Geology of the Coastal Plains</u>	3
4.2 <u>Faults</u>	4
4.3 <u>Hazardous Material</u>	4
4.4 <u>Site Stratigraphy and Geotechnical Characterization</u>	4
4.5 <u>Groundwater</u>	4
4.6 <u>Subsurface Variations</u>	5
5.0 <u>GEOTECHNICAL ENGINEERING RECOMMENDATIONS</u>	5
5.1 <u>General</u>	5
5.2 <u>Allowable Bearing Capacity</u>	6
5.3 <u>Lateral Earth Pressure</u>	7
5.4 <u>Trench Excavation Considerations</u>	8
5.5 <u>Bottom Stability</u>	10
5.6 <u>Hydrostatic Uplift</u>	10
5.7 <u>Excavation Dewatering</u>	10
6.0 <u>LIMITATIONS</u>	11
7.0 <u>DESIGN REVIEW</u>	12
8.0 <u>CONSTRUCTION MONITORING</u>	12
9.0 <u>AUTHORIZATION</u>	12
10.0 <u>GENERAL</u>	12
11.0 <u>CLOSING REMARKS</u>	13

GEOTECHNICAL INVESTIGATION
SURFACE WATER TRANSMISSION PROGRAM
AIR VALVE AND MANHOLE RECONSTRUCTION
FEDERAL, IH-10, IH-610, MCCARTY & KELLY
HOUSTON, TEXAS
GFS NO. S-0701-02-2; FILE NO. WA10775

PLATES

PLATES

Plate 1 Vicinity Map

APPENDICES

APPENDIX A

Plates A-1	Boring Location Plans
Plates A-2 thru A-18	Boring Logs
Plate A-19	Key to Symbols
Plate A-20	ASTM Designation for Soil Laboratory Tests
Plate A-21	Sieve Analysis Test Results
Plates A-22a thru A-22e	Generalized Soil Profiles

APPENDIX B

Plates B-1 thru B-7 Piezometer Installation Details

APPENDIX C

Plate C-1 OSHA Soil Classification for Excavation Trenching and Shoring

APPENDIX D

Plate D-1	Critical Heights
Plate D-2	Maximum Allowable Slopes
Plate D-3	A Combination of Bracing and Open Cut
Plate D-4	Logarithmic Spiral Method For Calculating Earth Pressure Against Bracing
Plate D-5	Lateral Pressure Diagrams - For Open Cuts in Cohesive Soils - Long Term Conditions
Plate D-6	Lateral Pressure Diagrams - For Open Cuts in Cohesive Soils - Short Term Conditions
Plate D-7	Lateral Pressure Diagrams - For Open Cuts in Sand - Long Term Conditions
Plate D-8	Lateral Pressure Diagrams - For Open Cuts in Sand - Short Term Conditions
Plate D-9	Bottom Stability for Braced Excavation
Plate D-10	Uplift Pressure and Resistance

EXECUTIVE SUMMARY

Aviles Engineering Corporation (AEC) performed a geotechnical investigation for the construction of manholes at the location of air valves along existing water transmission lines located along Federal Road, IH-10, IH-610, McCarty and Kelly in Houston, Texas. The manholes will be installed at an invert depth of about 10 feet below existing grades using open-cut construction methods.

As requested, subsurface conditions were investigated by drilling 17 soil borings (B-1 to B-17) to a depth of 15 feet each; seven of the borings were converted to piezometers upon completion. The general subsurface stratigraphy consists of a surface layer of fill overlying alternating layers of firm to stiff clay (CH) and sandy clay (CL). The clays have shiny planes of weakness and fissures; such soils often fail along these planes when they are not confined laterally. The fill soils extend to depths of about two to 10 feet in the borings and consist of very soft to stiff clay and sandy clay. In Boring B-4, water-bearing, sandy silt and silty sand extend from a depth of about 6 feet to the 15-foot termination depth of the boring.

Groundwater depths varied along the alignment; groundwater was not encountered in all borings. Where encountered, the groundwater depths ranged from about 4 to 13 feet during drilling. The groundwater was at a depth of about 2.5 to 10.9 feet in the piezometers about 3 weeks after installation of the piezometers. Based on the subsurface conditions revealed by the soil borings, the following findings and recommendations are presented:

1. We did not note any evidence of hazardous material in the samples recovered from the borings.
2. We evaluated fault locations by reviewing in-house documented fault maps. The site is located within the Clinton Salt Dome which is associated with numerous faults.
3. OSHA soil classifications (based on soil conditions encountered during our investigation), trench protection requirements, and bracing design parameters are presented in Appendix C.
4. Groundwater depths and seepage rates will depend on the time of year and of construction. The Contractor should be prepared to dewater excavations. A sump and pump arrangement is typically used where cohesive soils occur; where water-bearing granular soils are encountered (such as in Boring B-4), vacuum well points or deep wells with submersible pumps may be required.
5. Our borings indicate that the manhole foundation soils consist of stiff to very stiff cohesive soils and medium dense sand. Allowable net bearing capacities for the design of the manhole foundations are presented in Section 5.2 of this report.
6. Lateral earth soil parameters for the design of manhole walls are presented in Section 5.3 of this report.

7. It should be noted that this executive summary does not fully relay our findings and recommendations. Therefore, the entire report should be carefully reviewed and our findings and recommendations incorporated in the design and construction documents.

GEOTECHNICAL INVESTIGATION
SURFACE WATER TRANSMISSION PROGRAM
AIR VALVE AND MANHOLE RECONSTRUCTION
FEDERAL, IH-10, IH-610, MCCARTY & KELLY
HOUSTON, TEXAS
GFS NO. S-0701-02-2; FILE NO. WA10775

1.0 INTRODUCTION

1.1 General

This report presents the results of our geotechnical investigation for the City of Houston Surface Water Transmission Program (SWTP), GFS No. S-0701-02-2, File No. WA10775.

1.2 Location and Description of Project

The project will consist of the construction of manholes at the locations of air valves along existing water transmission lines. Based on information provided by Lockwood, Andrews & Newnam, Inc. (LAN), the manholes will be installed at an invert depth of about 10 feet below existing grade using open-cut construction methods. The affected water transmission lines and their associated air valves are summarized in Table 1 below. A vicinity map is presented on Plate 1.

Table 1. Water Transmission Lines and Associated Air Valves

Location of Water Transmission Line			Air Valve No.
From	Along	To	
East Water Purification Plant	Federal Road	IH-10	6 through 8
Federal Road @ IH-10	North Feeder Road of IH-10	IH-610	9 through 19
IH-10 @ IH-610	East Feeder Road of IH-610	McCarty	20 through 23
McCarty	North Feeder Road of IH-610	Kelly	24 through 26
Kelly @ IH-610	Kelly	Pickfair	29

1.3 Scope of Work

The scope of our investigation included:

- performing field exploration, laboratory testing and engineering analysis, and
- providing geotechnical recommendations to guide the design and construction of the manholes.

2.0 SUBSURFACE INVESTIGATION PROGRAM

As requested, 17 soil borings (Borings B-1 through B-17) were drilled to a depth of 15 feet each for the subsurface investigation program. The boring numbers, boring depths and associated air valve numbers are listed in Table 2 below. The borings were drilled using a truck-mounted drilling rig, at the approximate locations shown on the Boring Location Plan, Plate A-1, Appendix A.

Table 2. Summary of Soil Boring Locations and Depths

Valve #	Boring No.	Boring Depth (ft)	Piezometer Depth (ft)
6	B-1	15	15
7	B-2	15	
8	B-3	15	
9 & 10	B-4	15	
11	B-5	15	15
12	B-6	15	
15	B-7	15	
16	B-8	15	15
17	B-9	15	
18	B-10	15	15
19	B-11	15	
20	B-12	15	15
21	B-13	15	
24	B-14	15	
25	B-15	15	15
26	B-16	15	
29	B-17	15	15

Soil samples were obtained from the borings using 3-inch-diameter, thin-wall, seamless steel, Shelby tube samplers in general accordance with ASTM D-1587. The strength of cohesive soils was estimated in the field using a pocket penetrometer. Undisturbed samples of cohesive soils were extruded mechanically from the core barrels in the field, wrapped in aluminum foil, and sealed in plastic bags to reduce moisture loss and disturbance. The samples were then placed in core boxes and transported to our laboratory for testing. Seven of the borings (Borings B-1, B-5, B-8, B-10, B-12, B-15, B-17) were converted to piezometers on completion. Piezometer installation details are presented on Plates B-1 through B-7, in Appendix B.

3.0 LABORATORY TESTING PROGRAM

The samples were examined and classified in the laboratory by a geotechnical engineering technician under engineering supervision. AEC's project engineer reviewed the field data and selected soil samples for laboratory tests to evaluate the engineering properties of the subsurface soils.

Atterberg limits, moisture content, sieve analysis and percent passing No. 200 sieve tests were performed on selected samples to estimate the index properties and confirm field soil classification. Strength of cohesive soils was estimated by performing unconfined compression tests on undisturbed samples. Results of the lab tests, except the sieve analysis, are presented on the boring logs, Plates A-2 through A-18 in Appendix A. A key to the symbols used on the logs is presented on Plate A-19. ASTM designations for the laboratory tests are listed on Plate A-20. The sieve analysis test results are presented on Plate A-21.

4.0 SUBSURFACE AND SITE CONDITIONS

4.1 Geology of the Coastal Plains

The Houston area is situated on the Quaternary Coastal Plain of Texas and is located on the north flank of the Gulf Coast Geosyncline. Most of Houston is located on the nearly level, rather featureless depositional plains of the Lissie and Beaumont Formations.

The site is located in the Beaumont formation. The Beaumont formation was deposited on land near sea level in flat river deltas and in fresh water streams and flood plains. During the depositional period, the courses of the major streams and deltaic tributaries changed frequently generating a complex stratification of sand, silt and clay deposits. Stream courses were frequently diverted significant distances from a given point and the water overlying the soil, cut off from a drainage path, would evaporate. Such water, which would be highly alkaline, would precipitate large nodules of calcium nodules (calcareous nodules) throughout the surface of evaporation. With the coming of the Second Wisconsin Ice Age, the nearby sea withdrew, leaving the formation several hundred feet above sea level and permitting the soil to desiccate. The process of desiccation compressed the clays in the formation such that they became significantly over-consolidated to a large depth. In addition, the process of desiccation, together with the later re-wetting, produced a network of fissures and slickensides that are now closed but which represent potential planes of weakness in the soils.

4.2 Faults

We evaluated fault locations by reviewing in-house documented fault maps. The site is located within the Clinton Salt Dome which is associated with numerous faults.

4.3 Hazardous Material

We did not note any evidence of hazardous material in the samples recovered from the borings.

4.4 Site Stratigraphy and Geotechnical Characterization

Except in Boring B-4, the general subsurface stratigraphy consists of a surface fill stratum overlying alternating layers of firm to stiff clay (CH) and sandy clay (CL). The clays have shiny planes of weakness denoted as "slickensides"; such soils often fail along these planes when they are not confined laterally (such as in an unbraced excavation). The fill soils extend to depths of about two to 10 feet in the borings (these depths may vary between boring locations) and consist of very soft to stiff clay and sandy clay. In Boring B-4, water-bearing, sandy silt and silty sand extended from a depth of about 6 feet to the 15-foot termination depth of the boring.

Details of the soils encountered in the borings are presented on the boring logs. Subsurface profiles along the project alignment are presented on Plate A-22.

4.5 Groundwater

Groundwater was not encountered in all borings. Where encountered, the groundwater depths ranged from about 4 to 13 feet along the alignment. The groundwater depth measured in each boring during our field exploration and in the piezometers are summarized in Table 3 below.

Table 3. Measured Groundwater Depths

Boring	Approx. Groundwater Depth During Drilling (ft)	Piezometric Groundwater Depth (ft)
B-1	11.0	6.6 (2/12/02)
B-2	4.0	
B-3	13.0	
B-4	6.0	
B-5	13.0	10.9 (2/12/02)
B-6	-	
B-7	-	
B-8	-	8.5 (2/12/02)
B-9	6.0	
B-10	-	2.5 (2/12/02)
B-11	12.0	
B-12	7.0	3.0 (2/12/02)
B-13	13.0	
B-14	12.0	
B-15	-	8.0 (2/12/02)
B-16	13.0	
B-17	-	4.3 (2/12/02)

4.6 Subsurface Variations

The information in this report summarizes the conditions encountered in the borings on the dates the borings were drilled. Subsurface soil conditions and groundwater depths will vary between borings and at each boring, depending on seasonal rainfall and the time of year when construction is in progress.

5.0 GEOTECHNICAL ENGINEERING RECOMMENDATIONS

5.1 General

This report must be used in its entirety for this project. It should be noted that if construction is performed during the wet season or soon after the wet season, groundwater depths and subsurface soil conditions may change significantly from those presented in this report. Such changes could result in "pumping" of the subgrade soils, making them difficult to work with, possibly requiring subgrade treatment/excavation to depths greater than recommended in this report. At any given time, groundwater depths will vary from one location to another; also, groundwater depths at a given location will vary over time.

The manholes will be constructed at a depth of 10 feet below existing grade using open-cut construction methods. Specific recommendations for each manhole are presented below.

5.2 Allowable Bearing Capacity

The slab-type foundation for the manholes may be designed using the allowable net bearing pressures presented in Table 4 below.

Table 4. Allowable Net Bearing Pressures

Valve No.	Boring No.	Manhole Depth (ft)	Allowable Net Baring Pressure (psf)
6	B-1	10	2,000
7	B-2	10	2,000
8	B-3	10	2,000
9 & 10	B-4	10	3,000
11	B-5	10	2,000
12	B-6	10	2,000
15	B-7	10	2,200
16	B-8	10	2,200
17	B-9	10	3,000
18	B-10	10	3,000
19	B-11	10	2,500
20	B-12	10	2,200
21	B-13	10	2,200
24	B-14	10	2,500
25	B-15	10	2,500
26	B-16	10	2,500
29	B-17	10	2,200

The values shown include a factor of safety of 3. The net bearing pressure may be determined by:

1. Summing the weight of the load applied to the foundation, the weight of the foundation and the weight of soil backfill placed above the foundation.
2. Subtracting the weight of soil excavated from the foundation footprint area.
3. Dividing the result of Items 1 and 2 (above) by the base area (footprint) of the foundation.

5.3 Lateral Earth Pressure

Lateral earth pressures which a soil exerts on the walls of below-grade structures depend on the type of backfill, placement method, surcharge behind the wall, etc. Lateral pressures for designing the manholes, for level backfills, may be calculated using the equivalent fluid densities presented in Table 5 below.

TABLE 5. Design Soil Parameters for Manhole Walls (No Movement)

Soil Type	γ_{eq} (pcf)	γ'_{eq} (pcf)	K_0	Tan δ	C_a (psf)
Silty Sand/Sand	60	30	0.50	0.36	0
Cement-Stabilized Sand	51	26	0.43	0.43	0
Select Fill	79	40	0.61	0.27	0

Notes: (1) γ_{eq} = Unit weight for equivalent fluid pressure above water level, γ'_{eq} = unit weight for equivalent fluid pressure below water level.

(2) K_0 = Coefficient of at-rest earth pressure.

(3) Tan δ = Friction factor between soil and concrete.

(4) C_a = Ultimate adhesion between soil and concrete

(5) On-site fat clay should not be used as backfill

Lateral pressure resulting from construction equipment or other surcharge should be taken into account by adding the equivalent uniformly distributed surcharge to the design lateral pressure. Hydrostatic pressure, if any, should also be considered. The lateral earth pressure at depth z can be determined by:

$$P_h = \gamma_{eq}h_1 + \gamma'_{eq}h_2 + \gamma_w h_2 + K_0 q_s \quad \text{.....Equation (1)}$$

where, P_h = lateral pressure, psf,

$\gamma_{eq}, \gamma'_{eq}$ = as in Table 5,

h_1 = depth from ground surface to groundwater table,

$h_2 = z - h_1$, depth from groundwater table to considering point,

z = depth below ground surface,

γ_w = unit weight of water, 62.4 pcf,

K_0 = coefficient of at-rest earth pressure.

q_s = uniform surcharge pressure, psf.

Where below-grade wall movement is allowed (temporary excavations), such walls may be designed using the parameters presented in Table 6 below.

TABLE 6. Design Soil Parameters for Below-Grade Walls (Movement Allowed)

Soil Type	γ	γ'	C'	C_a	ϕ'	$\tan \delta$	K_0	K_a	K_p
Silty Sand/Sand	120	60	0	0	30	0.36	0.50	0.33	3.0
Cement-Stabilized Sand	120	60	0	0	35	0.43	0.43	0.27	3.7
Select Fill	130	70	0	0	23	0.27	0.61	0.44	2.3

- Notes: (1) γ = Unit weight of soil above water level, γ' = buoyant unit weight of soil.
(2) C' = Ultimate cohesion of soil for long-term condition; C_a = adhesion between soil and concrete
(3) ϕ' = Friction angle of soil for long-term condition; $\delta = 0.67 \phi'$
(4) K_0 = Coefficient of at-rest earth pressure; K_a = Coefficient of active earth pressure; K_p = Coefficient of passive earth pressure;
(5) $\tan \delta$ = Friction factor between soil and concrete.
(6) On-site fat clay should not be used as backfill.

5.4 Trench Excavation Considerations

The Contractor should be responsible for designing, constructing, monitoring and maintaining safe excavations. The excavations should not cause any distress to existing structures; the structures should be monitored prior to, during and after construction to check for movements and necessary action taken promptly should movements be detected. Excavations may be shored, sheeted and braced, laid back to a stable slope, or other appropriate means may be used to ensure the safety of workers, public and adjacent structures. Excavation and trenching should be in accordance with OSHA Safety and Health Regulations, 29 CFR, Part 1926. OSHA Soil Types presented in Appendix C represent conditions encountered in the borings during our investigation and may vary between borings and be different during construction.

The Contractor should be aware that some of the cohesive soils encountered along the project alignment are susceptible to sloughing or caving because they have numerous fissures and weak failure plains. The fill soils have variable strengths and are very soft at some locations (for example, Boring B-16); such soils may also be encountered elsewhere along the alignment. In Boring B-4, water-bearing granular soils were encountered at a shallow depth; granular soils are inherently unstable. Again, such conditions may be encountered elsewhere along the alignment.

Critical Height In cohesive soils, critical height is defined as the height a slope will stand unsupported for a short time; it is used to estimate the maximum depth of open cuts at given side slopes. Critical height may be calculated based on soil cohesion. Plate D-1 (Appendix D) shows critical heights for various slopes and cohesion. The presence of fissures in the cohesive soils encountered at the site may reduce the critical height at this project. Cautions listed below should be exercised in critical height applications:

1. No more than 50 percent of the Critical Height computed should be used for vertical slopes. Unsupported vertical slopes are not recommended where granular soils or other unsuitable soils are encountered within the excavation depth.
2. If the soil at the surface is dry to the point where tension cracks occur, any water in the crack will increase the lateral pressure considerably. If tension cracks occur, no cohesion should be assumed for the soils within the depth of the crack. The first waler should be above the depth of the tension crack. Struts should be installed before lateral displacement occurs.
3. Shoring should be provided for excavations where limited space precludes adequate side slopes, e.g., where granular soils will not stand on stable slopes and/or for deep open cuts.
4. All excavation, trenching and shoring should be designed and constructed by qualified professionals in accordance with OSHA requirements.

Cut Slopes Plate D-2, in Appendix D presents the maximum (steepest) allowable slopes in Soil Types A, B and C for excavations less than 20 feet. If limited space is available for the required open trench side slopes, a combination of bracing and open cut may be used as illustrated on Plate D-3. Guidelines for bracing and calculating bracing stress are presented below.

Computation of Bracing Pressures A logarithmic spiral method is used for calculating earth pressure against bracing for open-cuts. This concept is illustrated on Plate D-4. For practical application, the pressure is obtained by the following relationship:

$$P_a = 1.1 P_A \quad \text{.....Equation (2)}$$

where: P_a = Maximum Pressure (psf)

1.1 = Dimensionless Coefficient

$P_A = \text{Active Pressure (psf)} = K_a \gamma D$

where: K_a = Coefficient of Active Earth Pressure

γ = Soil Density (pcf)

D = Depth of Soil (ft)

The design load (L) for struts in open-cut in sand is obtained by the following relationship:

$$L = 0.8 P_a \cos \delta \quad \text{.....Equation(3)}$$

where: L = Design Load (psf)

$\tan \delta = 2/3 \tan (\text{angle of soil friction})$

example: if $\phi = 41^\circ$, $\delta = 30^\circ$ (dense to very dense)

example: if $\phi = 30^\circ$, $\delta = 21^\circ$ (loose to medium dense)

Pressure distribution for the design of struts in open-cuts for clay and sand are illustrated on Plates D-5 through D-8. If there is water behind the bracing, hydrostatic pressure should be included in the design. In addition, sloped soils and traffic loads should also be included in the bracing design, if applicable.

5.5 Bottom Stability

If tight sheeting is terminated at the base of a braced cut in cohesionless soil, (Boring B-4) the bottom of the excavation can become unstable depending on the differential hydrostatic head between the inside and outside of the excavation and the length of penetration of the sheeting into the granular stratum. In granular soils, excavations should be made after dewatering is accomplished to reduce potential bottom stability problems. The sheeting should extend into stiff cohesive soils located below the granular soil stratum if possible or the length of the penetration of the sheeting into the granular stratum should be increased. For cuts in cohesive soils, stability of the bottom can be evaluated according to the procedure outlined on Plate D-9. If the safety factor is less than 1.5, the sheeting should extend to a depth of "D₁" below the base of the excavation as shown.

5.6 Hydrostatic Uplift

We recommend that the manholes be designed to resist uplift based on the buoyant weight of the structures. In open-cut construction, additional uplift resistance can be provided by extending the foundation sufficiently beyond the outer face of the vertical walls to provide the required weight of overburden soil to resist uplift. The minimum recommended factors of safety against uplift should be 1.1 for concrete weight, 1.5 for soil weight and 3.0 soil friction. Recommended soil design parameters for use in computing uplift resistance, shown on Plate D-10, are presented below:

Unit weight of water = 62.4 pcf

Wet unit weight of soil = 120 pcf

Submerged unit weight of backfill or natural soil = 60 pcf

Submerged unit weight of concrete = 90 pcf

Coefficient of earth pressure = 1.0

5.7 Excavation Dewatering

The Contractor should be responsible for designing, installing and maintaining dewatering systems for groundwater control. Since groundwater conditions vary over time, we recommend that the Contractor

investigate the groundwater/seepage conditions at the start of construction and use the results to design the dewatering system; the groundwater depths and seepage rates during construction may be different from that shown in this report. The dewatering system should be designed and installed by qualified and experienced professionals who are also capable of monitoring, maintaining and modifying the system, as required. The following discussion provides general guidelines to the Contractor for dewatering.

Dewatering should be in accordance with COH Standard Specifications, Section 01578 - Control of Ground Water and Surface Water. The design of the system should consider the effect of dewatering on adjacent structures. The Contractor should monitor nearby structures along the proposed alignment to ensure that the dewatering does not result in any distress or detrimental effects on these structures.

Excavation in cohesive soils can generally be dewatered by draining the groundwater into sump pits and pumping it out. Excavation in water-bearing cohesionless soils (such as may be encountered in the vicinity of Boring B-4) are typically controlled by installation of vacuum well points or deep wells with submersible pumps. The practical maximum depth for the use of vacuum well points is considered to be about 15 feet. Where groundwater control is required below 15 feet, deep wells with submersible pumps have generally proven successful. On some occasions, eductor wells have been used in lieu of wells with submersible pumps. Dewatering should lower the groundwater depth at least 3 feet below the excavation bottom to provide a dry condition for workers.

Although groundwater was not encountered in some of the borings during drilling, this does not necessarily that groundwater will not be present at other times. We recommend that the Contractor be prepared to dewater the excavations in the event groundwater is encountered during construction.

In Boring B-11, the groundwater rose to a depth of 11 feet from an initial depth of 12 feet within ½ hour; in Boring B-16, the groundwater rose to a depth of 10 feet from an initial depth of 13 feet within ½ hour. This rise in water levels suggests that the groundwater may be under pressure along some sections of the project alignment; the Contractor should be aware of these conditions during preparation of his bid.

6.0 LIMITATIONS

This investigation was performed using the standard level of care and diligence normally practiced by recognized geotechnical engineering firms in this area, presently performing similar services under similar circumstances. The report has been prepared exclusively for the project and location described in this report

and is intended to be used in its entirety. If pertinent project details change or otherwise differ from those described herein, AEC should be notified immediately and retained to evaluate the effect of the changes on and revise the recommendations presented in this report. The recommendations presented in this report should not be used for other structures located along this alignment or similar structures located elsewhere, without additional evaluation and/or investigation.

7.0 DESIGN REVIEW

AEC should be authorized to review the construction plans and specifications prior to their release, to check that the geotechnical recommendations contained in this report have been properly interpreted.

8.0 CONSTRUCTION MONITORING

Construction should be monitored by qualified geotechnical personnel on a full-time basis to check for compliance with project documents and changed conditions.

9.0 AUTHORIZATION

This investigation was authorized by Mr. Rafael Ortega, P.E., with Lockwood, Andrews & Newnam, upon approval of AEC Revised Proposal No. G2003-12-01R, dated January 8, 2004.

10.0 GENERAL

The information contained in this report summarizes conditions found on the date the borings were drilled. The attached boring logs are true representations of the soils encountered at the specific boring locations on the dates of drilling. Reasonable variations from the subsurface information presented in this report should be anticipated. If conditions encountered during construction are significantly different from those presented in this report, AEC should be notified immediately.

11.0 CLOSING REMARKS

AEC appreciates the opportunity to be of service on this project and looks forward to our continuing association during the construction phase of this project and on future projects.

AVILES ENGINEERING CORPORATION

A. Chris Onuekwusi

A. Chris Onuekwusi, M.S.C.E., P.E.
Project Manager

Albert A. Joseph

Albert A. Joseph, M.E.(Civil), P.E.
Senior Engineer

February 27, 2004

Copies Submitted: 4 Lockwood, Andrews & Newnam, Inc.
 1 File

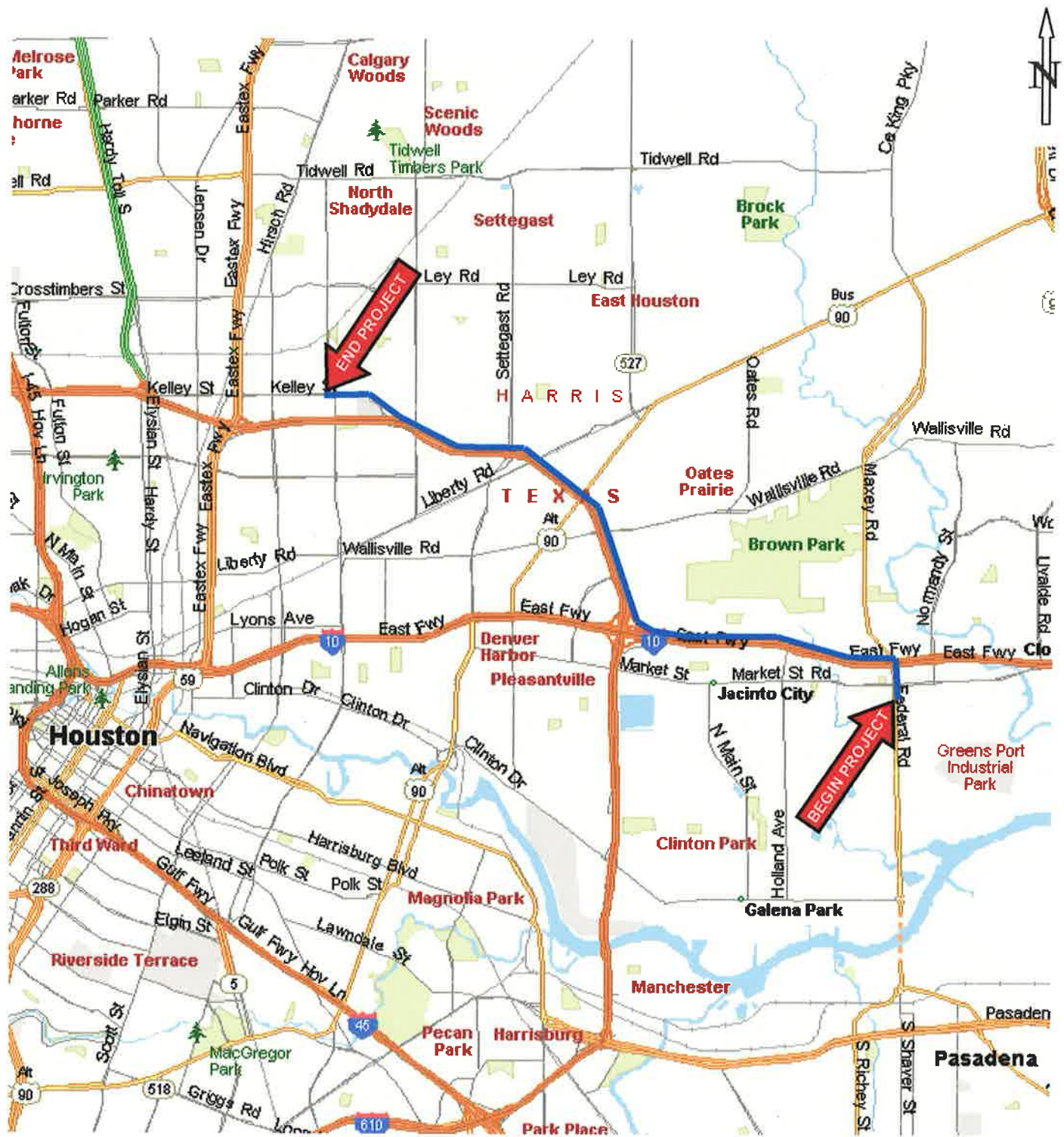
Z:\Engineering\reports\2004\G105-04\G105-04Final.wpd



PLATES

PLATES

Plate 1 Vicinity Map



AVILES ENGINEERING CORPORATION

VICINITY MAP **AIR VALVES & MANHOLES RECONSTRUCTION** **HOUSTON, TEXAS**

AEC PROJECT NO.	DATE:	
G105-04	02-19-04	
SCALE:	DRAWN BY:	PLATE NO.:
N.T.S.	B.P.J.	PLATE 1

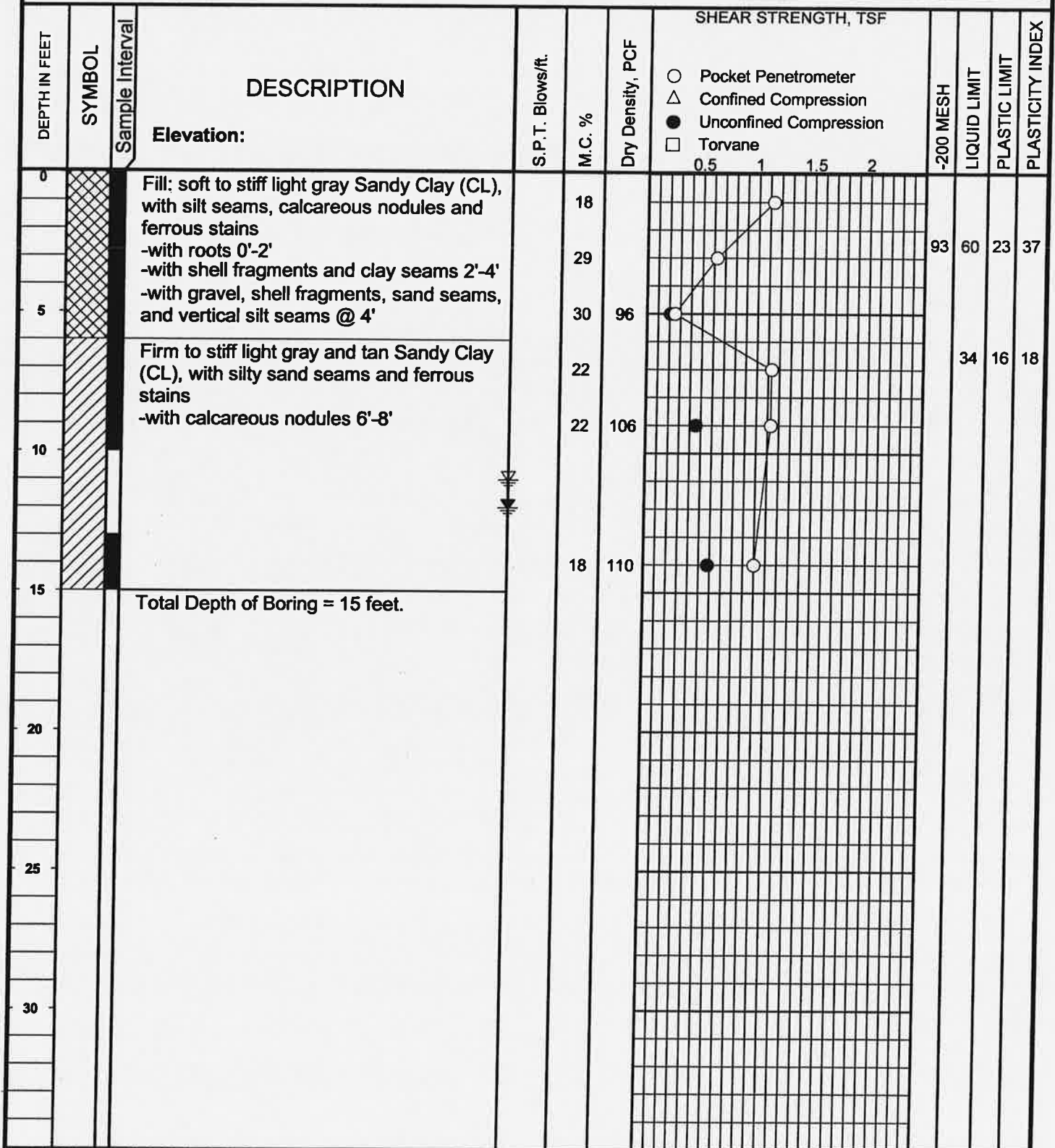
APPENDICES

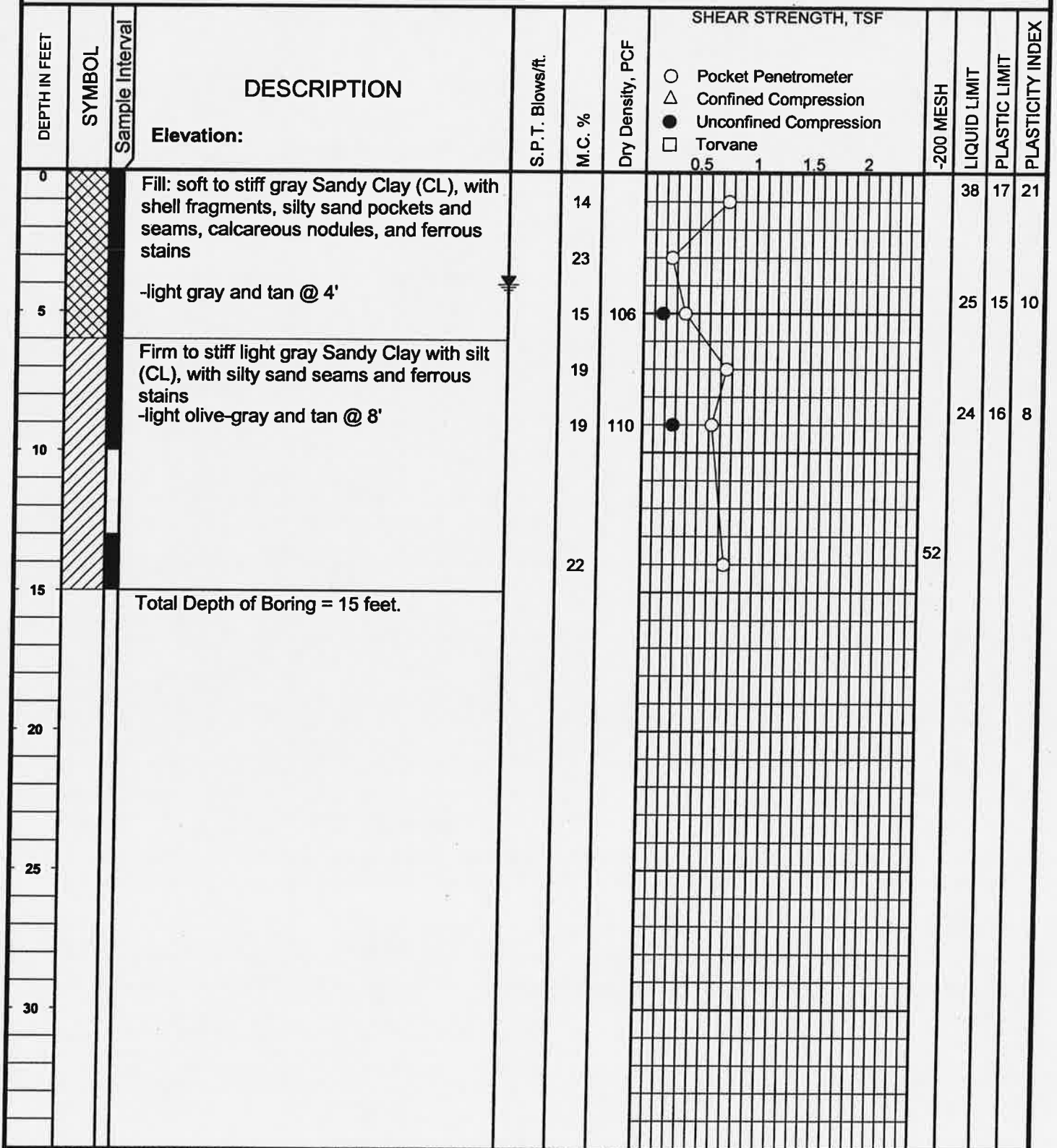
APPENDIX A

Plates A-1	Boring Location Plans
Plates A-2 thru A-18	Boring Logs
Plate A-19	Key to Symbols
Plate A-20	ASTM Designation for Soil Laboratory Tests
Plate A-21	Sieve Analysis Test Results
Plates A-22a thru A-22e	Generalized Soil Profiles



AVILES ENGINEERING CORPORATION		
BORING LOCATION PLAN		
AIR VALVES & MANHOLES RECONSTRUCTION HOUSTON, TEXAS		
AEC PROJECT NO. G105-04	DATE 02-19-04	
SCALE N.T.S.	DRAWN BY B.P.J.	PLATE NO. PLATE A-1

PROJECT: City of Houston Manhole ReconstructionBORING B-1DATE 02-06-04TYPE 4" AugerLOCATION See Boring Location PlanBORING DRILLED TO 15 FEET WITHOUT DRILLING FLUIDWATER ENCOUNTERED AT 11 FEET WHILE DRILLINGWATER LEVEL AT 12 FEET AFTER 1/2 HOURSDRILLED BY J.H. Drilling CHECKED BY A.C.O. LOGGED BY J.H. Drilling

PROJECT: City of Houston Manhole ReconstructionBORING B-2DATE 02-06-04TYPE 4" AugerLOCATION See Boring Location PlanBORING DRILLED TO 15 FEET WITHOUT DRILLING FLUIDWATER ENCOUNTERED AT 4 FEET WHILE DRILLINGWATER LEVEL AT 4 FEET AFTER 1/2 HOURSDRILLED BY J.H. Drilling CHECKED BY A.C.O. LOGGED BY J.H. Drilling

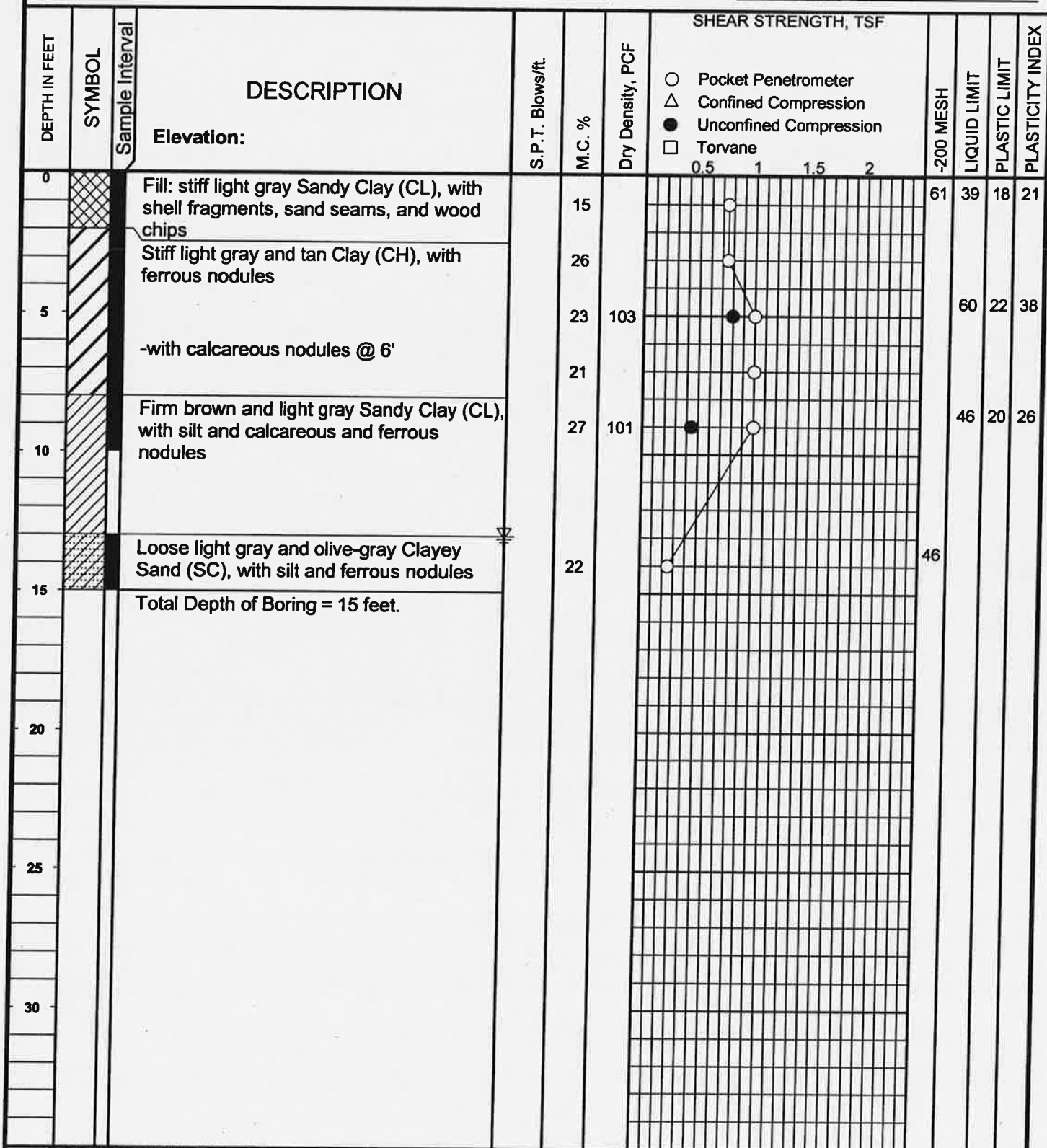
PROJECT: City of Houston Manhole Reconstruction

BORING B-3

DATE 01-20-04

TYPE 4" Auger

LOCATION See Boring Location Plan



BORING DRILLED TO 15 FEET WITHOUT DRILLING FLUID

WATER ENCOUNTERED AT 13 FEET WHILE DRILLING

WATER LEVEL AT 13 FEET AFTER 0 HOURS

DRILLED BY J.H. Drilling CHECKED BY Z.Y. LOGGED BY J.H. Drilling

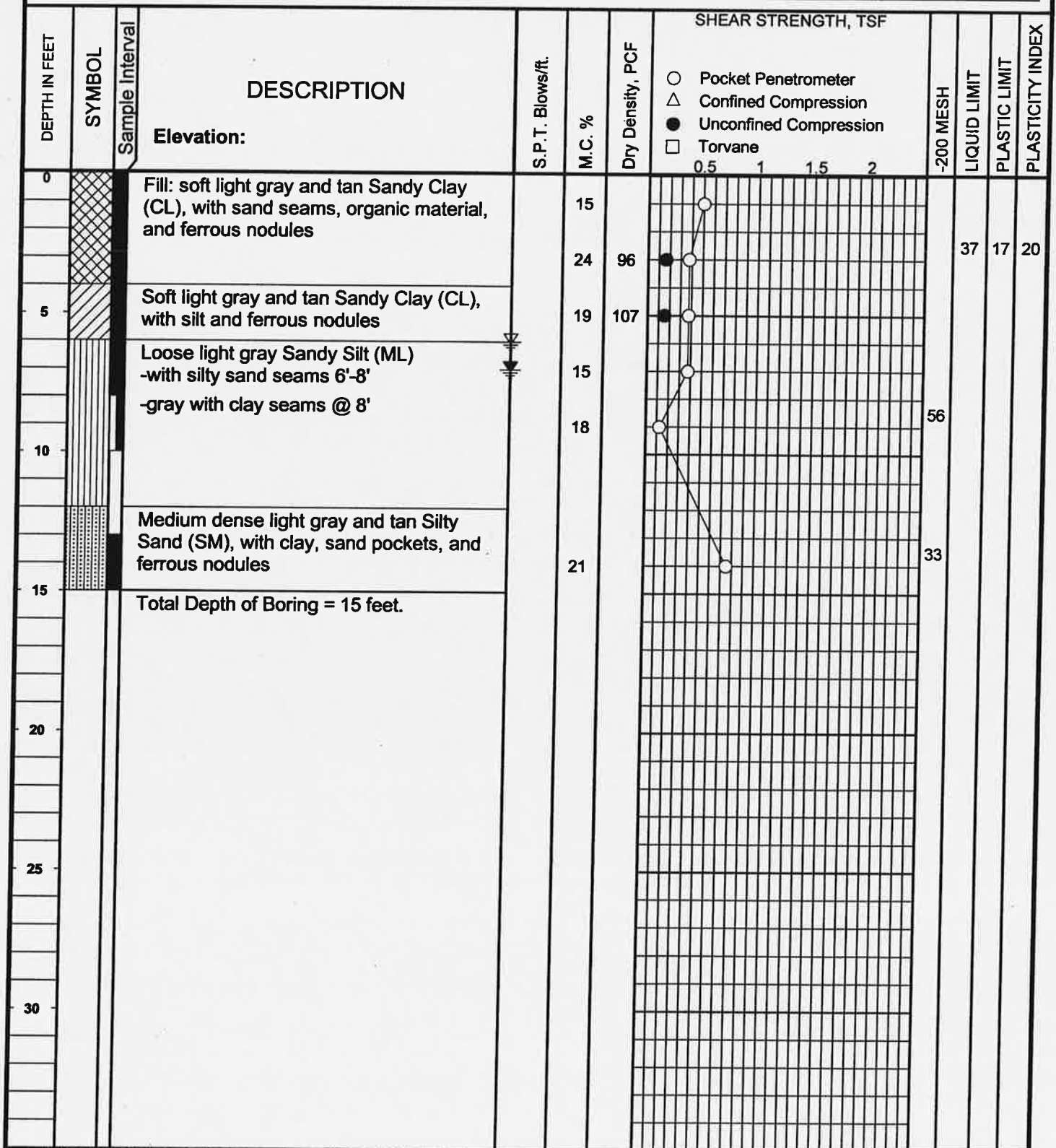
PROJECT: City of Houston Manhole ReconstructionBORING B-4DATE 01-20-04TYPE 4" AugerLOCATION See Boring Location PlanBORING DRILLED TO 15 FEET WITHOUT DRILLING FLUIDWATER ENCOUNTERED AT 6 FEET WHILE DRILLINGWATER LEVEL AT 7 FEET AFTER 1/2 HOURSDRILLED BY J.H. Drilling CHECKED BY Z.Y. LOGGED BY J.H. DrillingPROJECT NO. G105-04

PLATE A-5

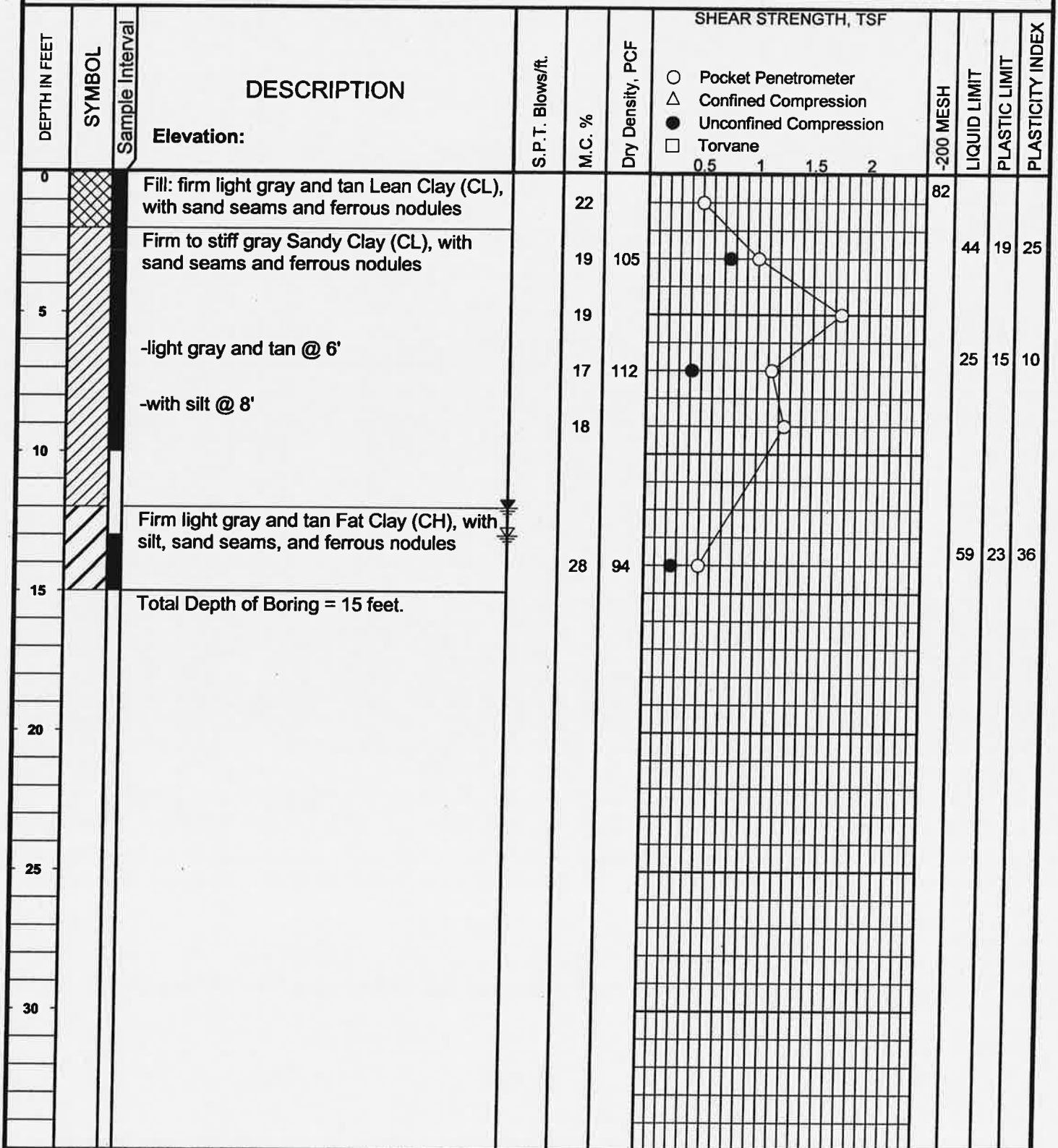
PROJECT: City of Houston Manhole Reconstruction

BORING B-5

DATE 01-20-04

TYPE 4" Auger

LOCATION See Boring Location Plan

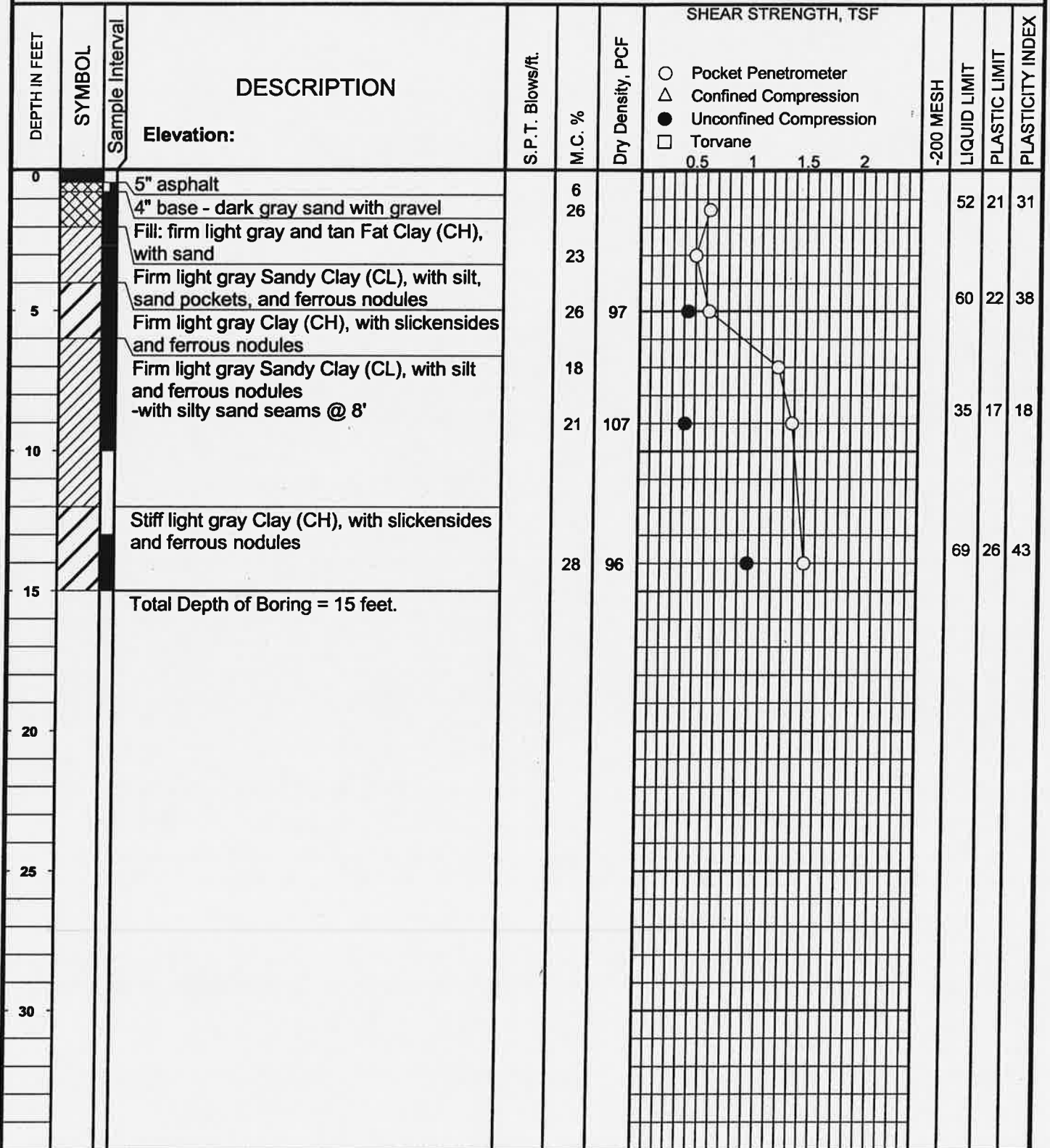


BORING DRILLED TO 15 FEET WITHOUT DRILLING FLUID

WATER ENCOUNTERED AT 13 FEET WHILE DRILLING

WATER LEVEL AT 12 FEET AFTER 1/2 HOURS

DRILLED BY J.H. Drilling CHECKED BY Z.Y. LOGGED BY J.H. Drilling

PROJECT: City of Houston Manhole ReconstructionBORING B-6DATE 01-20-04TYPE 4" AugerLOCATION See Boring Location PlanBORING DRILLED TO 15 FEET WITHOUT DRILLING FLUIDWATER ENCOUNTERED AT 15 FEET WHILE DRILLINGWATER LEVEL AT 15 FEET AFTER 0 HOURSDRILLED BY J.H. Drilling CHECKED BY Z.Y. LOGGED BY J.H. Drilling

PROJECT: City of Houston Manhole Reconstruction

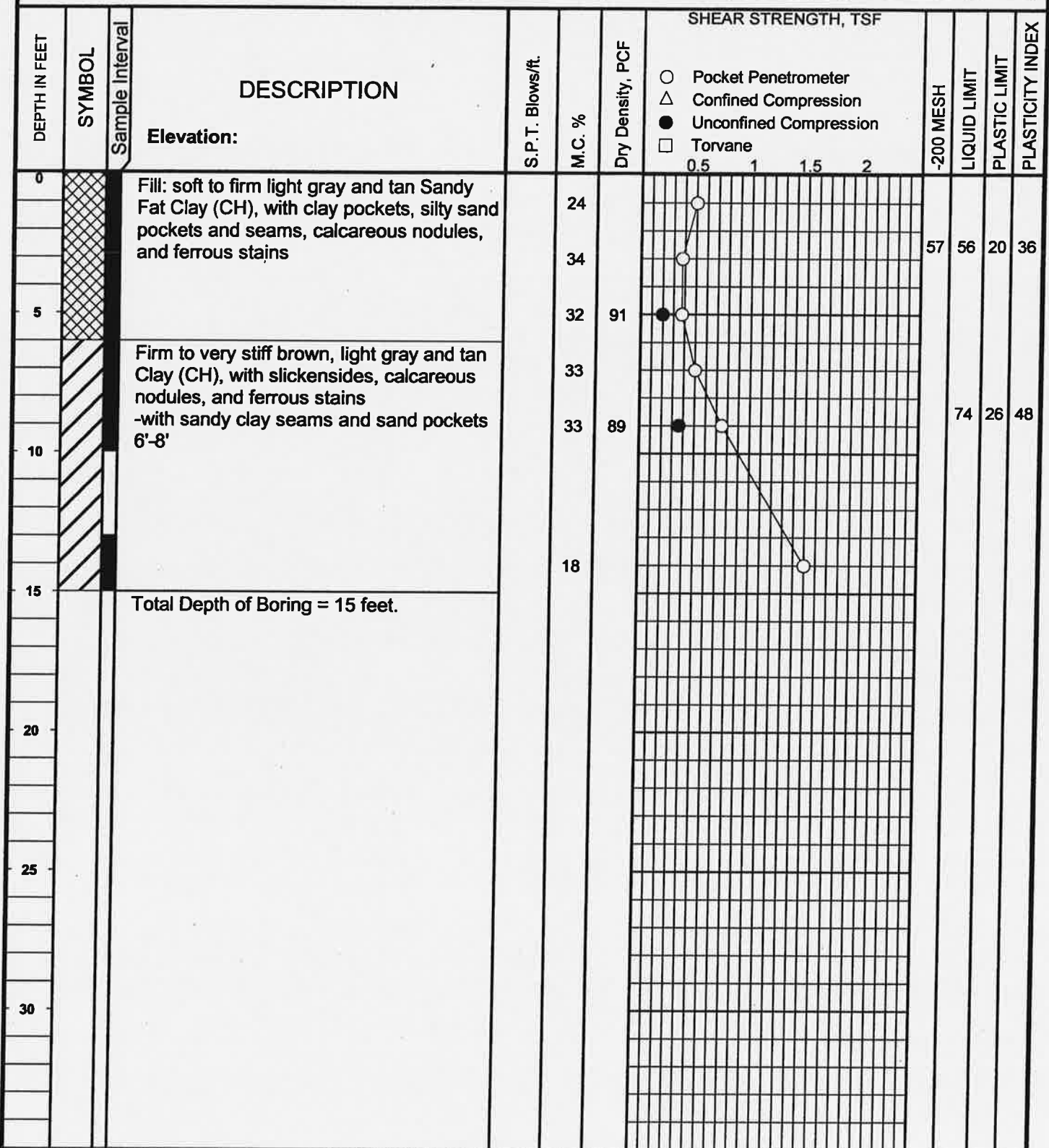
BORING

B-7

DATE 02-06-04

TYPE 4" Auger

LOCATION See Boring Location Plan



BORING DRILLED TO 15 FEET WITHOUT DRILLING FLUID

WATER ENCOUNTERED AT - FEET WHILE DRILLING

WATER LEVEL AT - FEET AFTER - HOURS

DRILLED BY J.H. Drilling CHECKED BY A.C.O. LOGGED BY J.H. Drilling

PROJECT: City of Houston Manhole Reconstruction

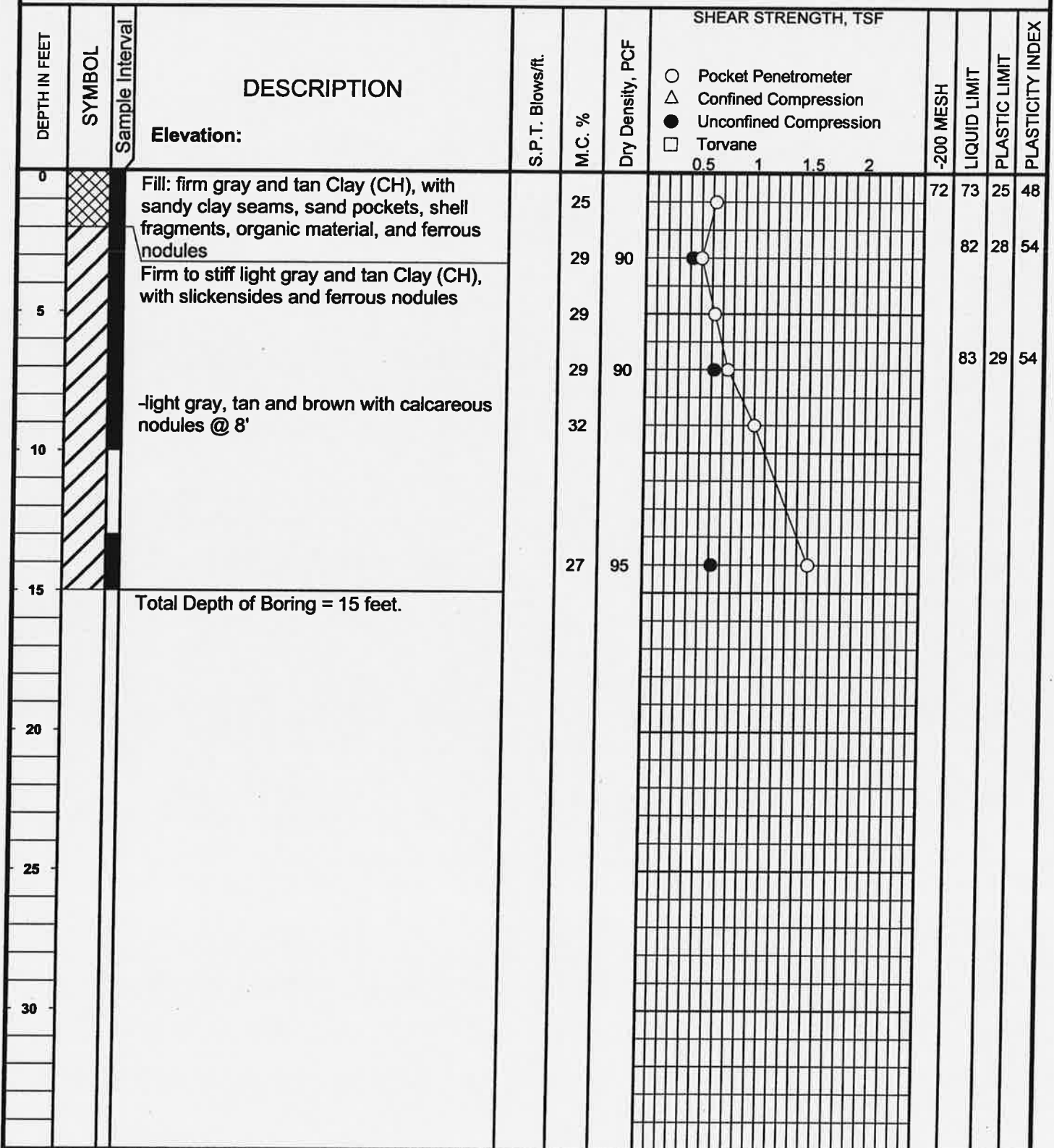
BORING

B-8

DATE 01-21-04

TYPE 4" Auger

LOCATION See Boring Location Plan



BORING DRILLED TO FEET WITHOUT DRILLING FLUID

WATER ENCOUNTERED AT FEET WHILE DRILLING

WATER LEVEL AT FEET AFTER HOURS

DRILLED BY J.H. Drilling CHECKED BY Z.Y. LOGGED BY J.H. Drilling

PROJECT: City of Houston Manhole Reconstruction

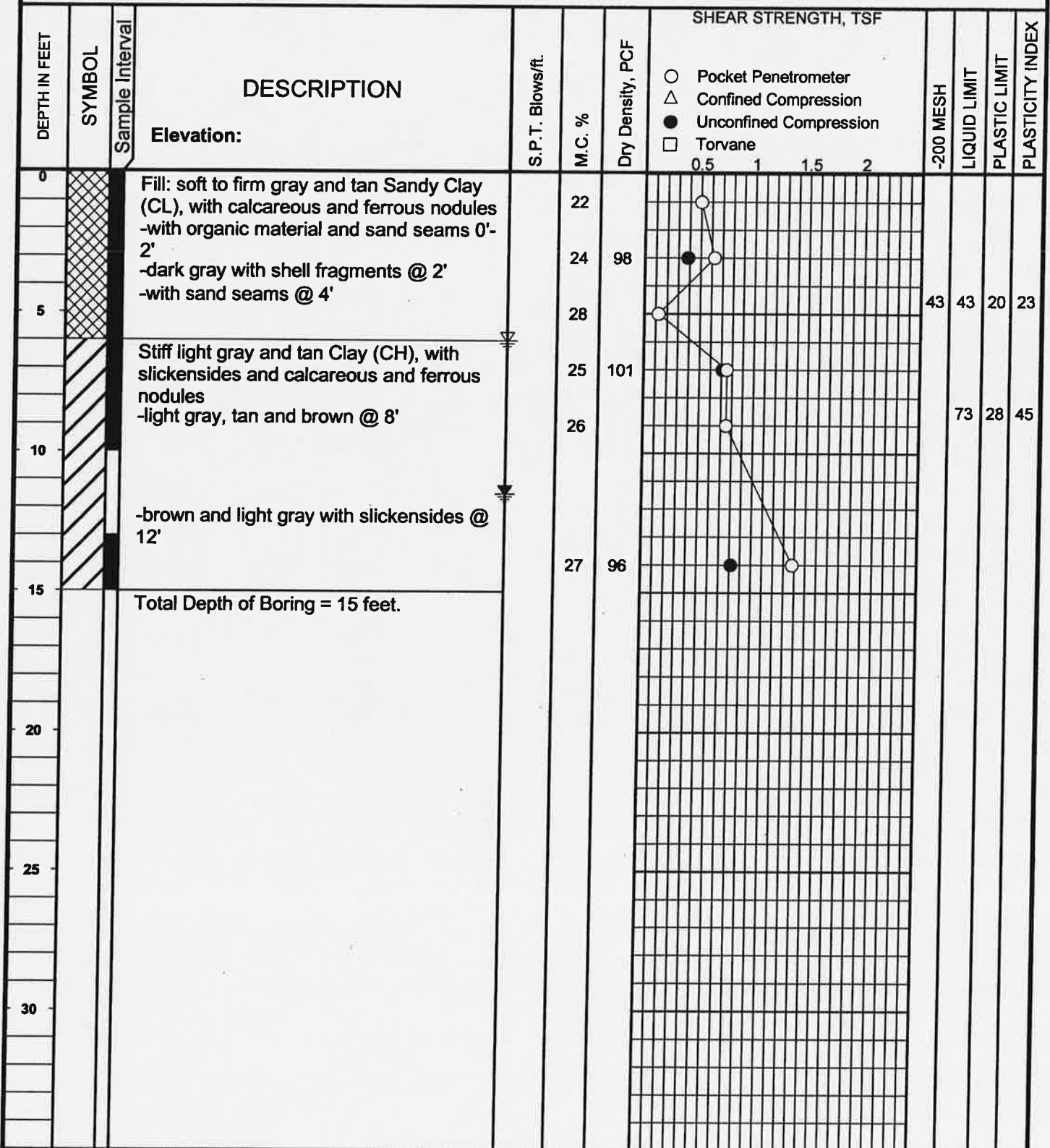
BORING

B-9

DATE 01-20-04

TYPE 4" Auger

LOCATION See Boring Location Plan



BORING DRILLED TO FEET WITHOUT DRILLING FLUID

WATER ENCOUNTERED AT 6 FEET WHILE DRILLING

WATER LEVEL AT 11.5 FEET AFTER 1/2 HOURS

DRILLED BY J.H. Drilling CHECKED BY Z.Y. LOGGED BY J.H. Drilling

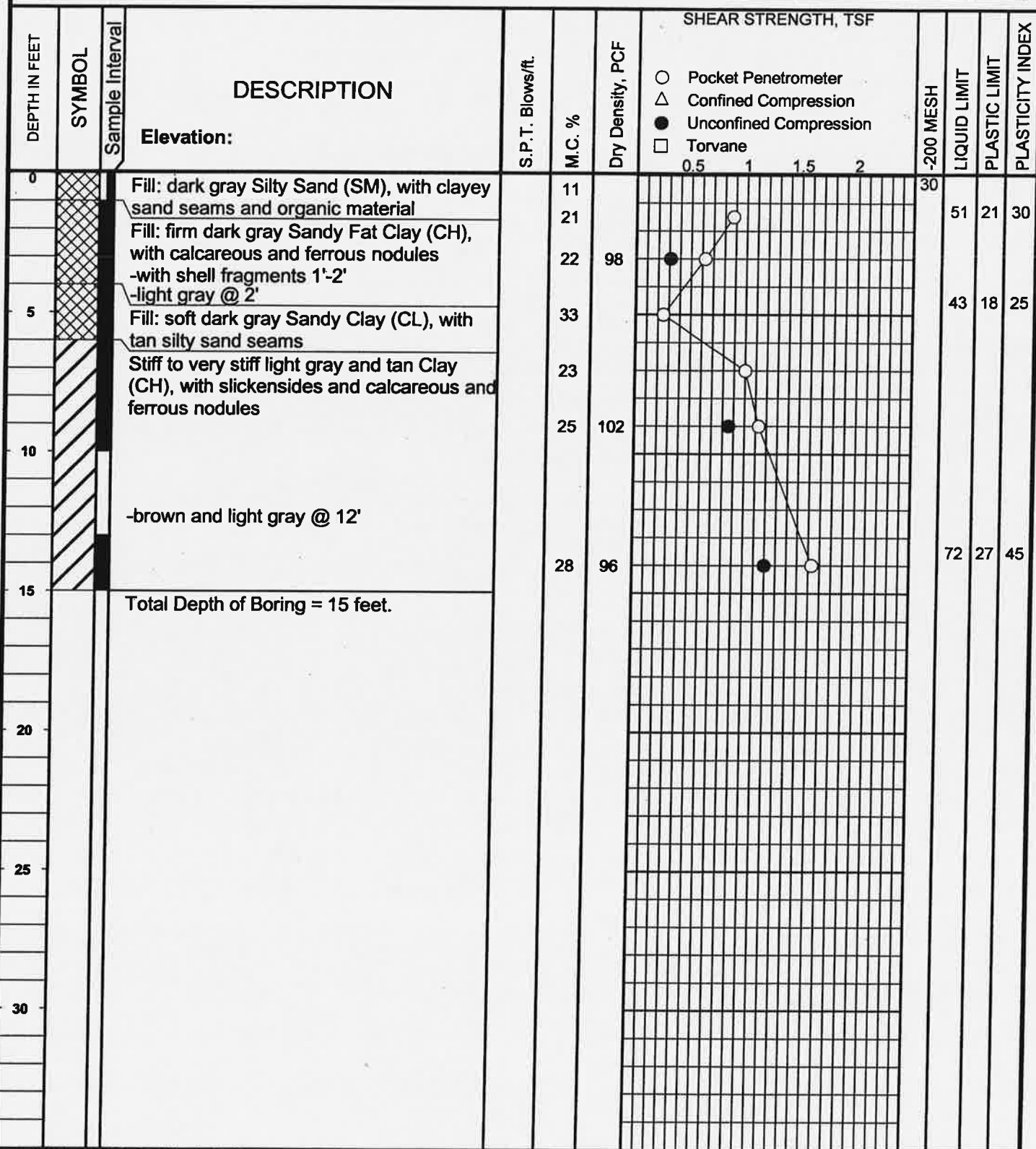
PROJECT: City of Houston Manhole Reconstruction

BORING B-10

DATE 01-20-04

TYPE 4" Auger

LOCATION See Boring Location Plan



BORING DRILLED TO 15 FEET WITHOUT DRILLING FLUID

WATER ENCOUNTERED AT - FEET WHILE DRILLING ≡

WATER LEVEL AT - FEET AFTER - HOURS ≡

DRILLED BY J.H. Drilling CHECKED BY Z.Y. LOGGED BY J.H. Drilling

PROJECT: City of Houston Manhole Reconstruction

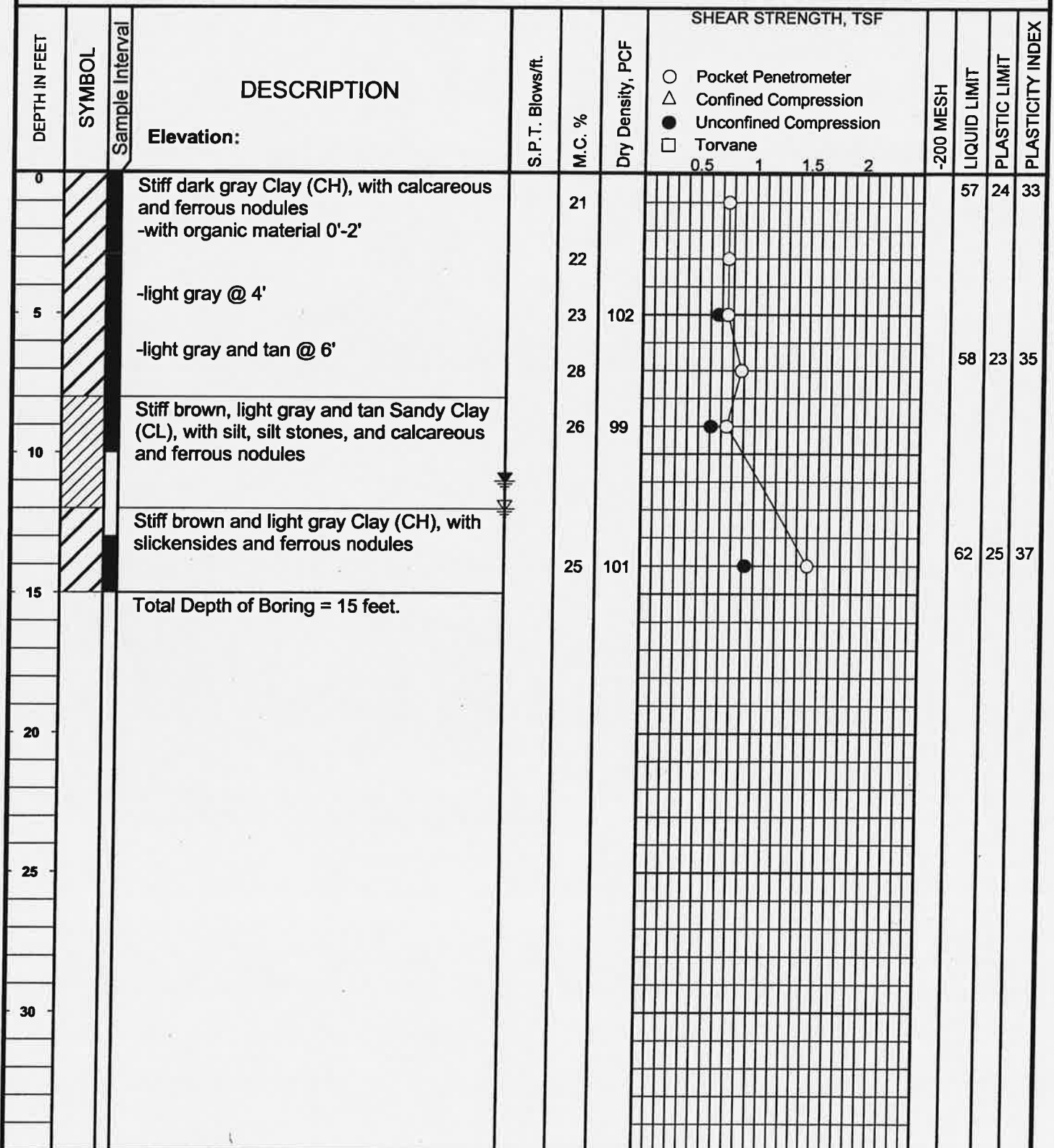
BORING

B-11

DATE 01-20-04

TYPE 4" Auger

LOCATION See Boring Location Plan



BORING DRILLED TO 15 FEET WITHOUT DRILLING FLUID

WATER ENCOUNTERED AT 12 FEET WHILE DRILLING

WATER LEVEL AT 11 FEET AFTER 1/2 HOURS

DRILLED BY J.H. Drilling CHECKED BY Z.Y. LOGGED BY J.H. Drilling

PROJECT: City of Houston Manhole Reconstruction

BORING

B-12

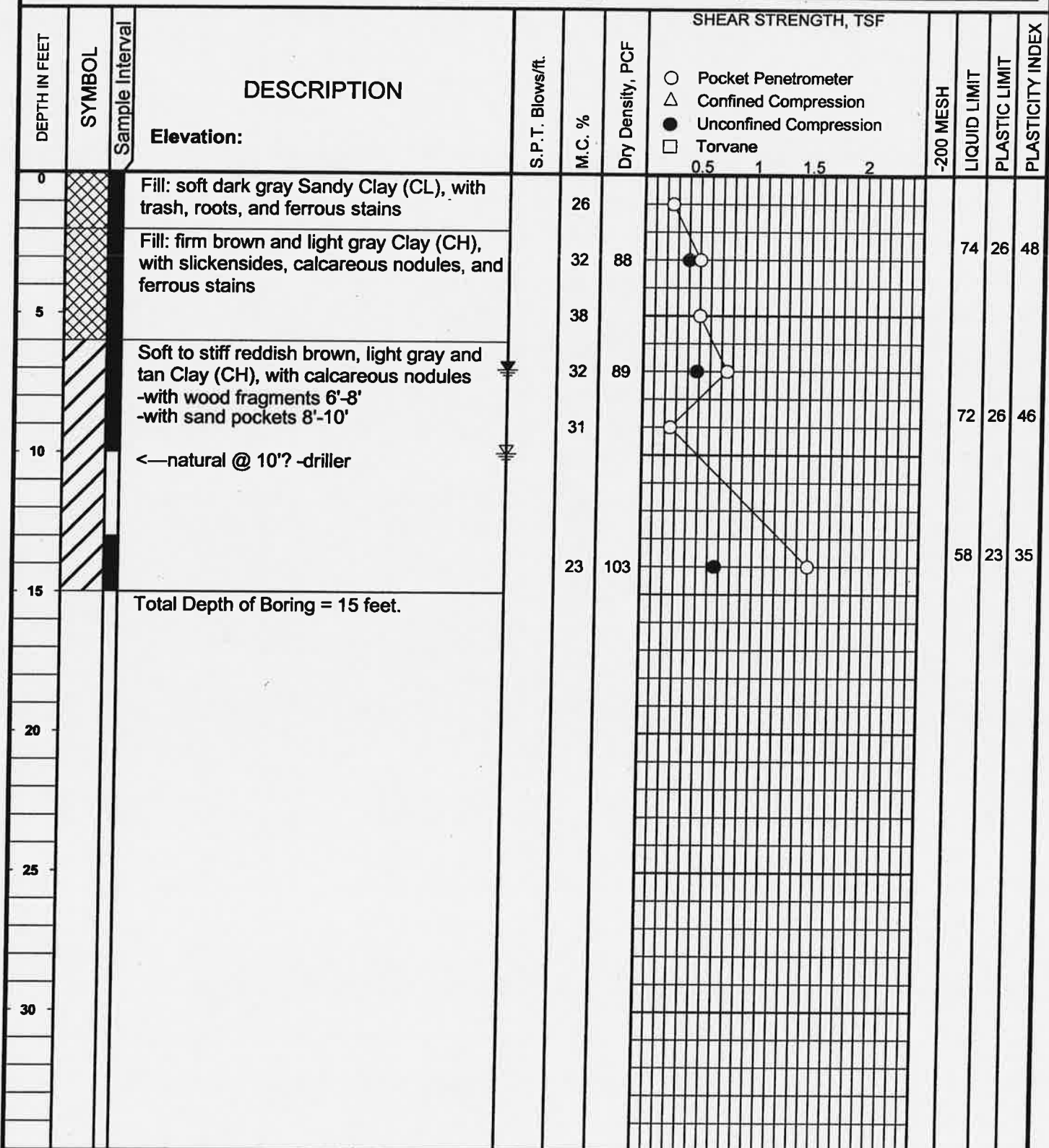
DATE 02-06-04TYPE 4" AugerLOCATION See Boring Location PlanBORING DRILLED TO 15 FEET WITHOUT DRILLING FLUIDWATER ENCOUNTERED AT 10 FEET WHILE DRILLINGWATER LEVEL AT 7 FEET AFTER 1/2 HOURSDRILLED BY J.H. Drilling CHECKED BY A.C.O. LOGGED BY J.H. DrillingPROJECT NO. G105-04

PLATE A-13

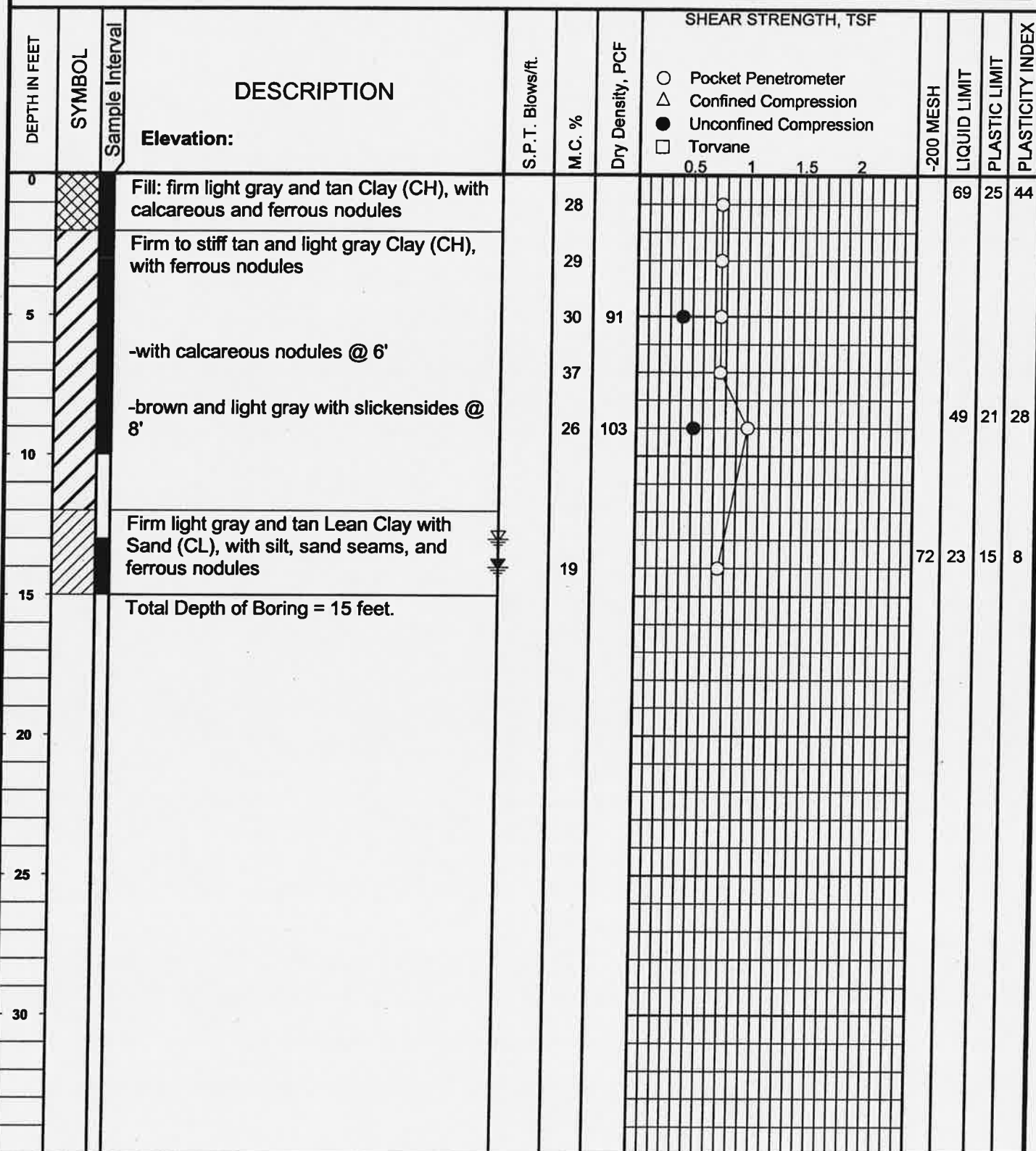
PROJECT: City of Houston Manhole Reconstruction

BORING B-13

DATE 01-20-04

TYPE 4" Auger

LOCATION See Boring Location Plan



BORING DRILLED TO 15 FEET WITHOUT DRILLING FLUID

WATER ENCOUNTERED AT 13 FEET WHILE DRILLING

WATER LEVEL AT 14 FEET AFTER 1/2 HOURS

DRILLED BY J.H. Drilling CHECKED BY Z.Y. LOGGED BY J.H. Drilling

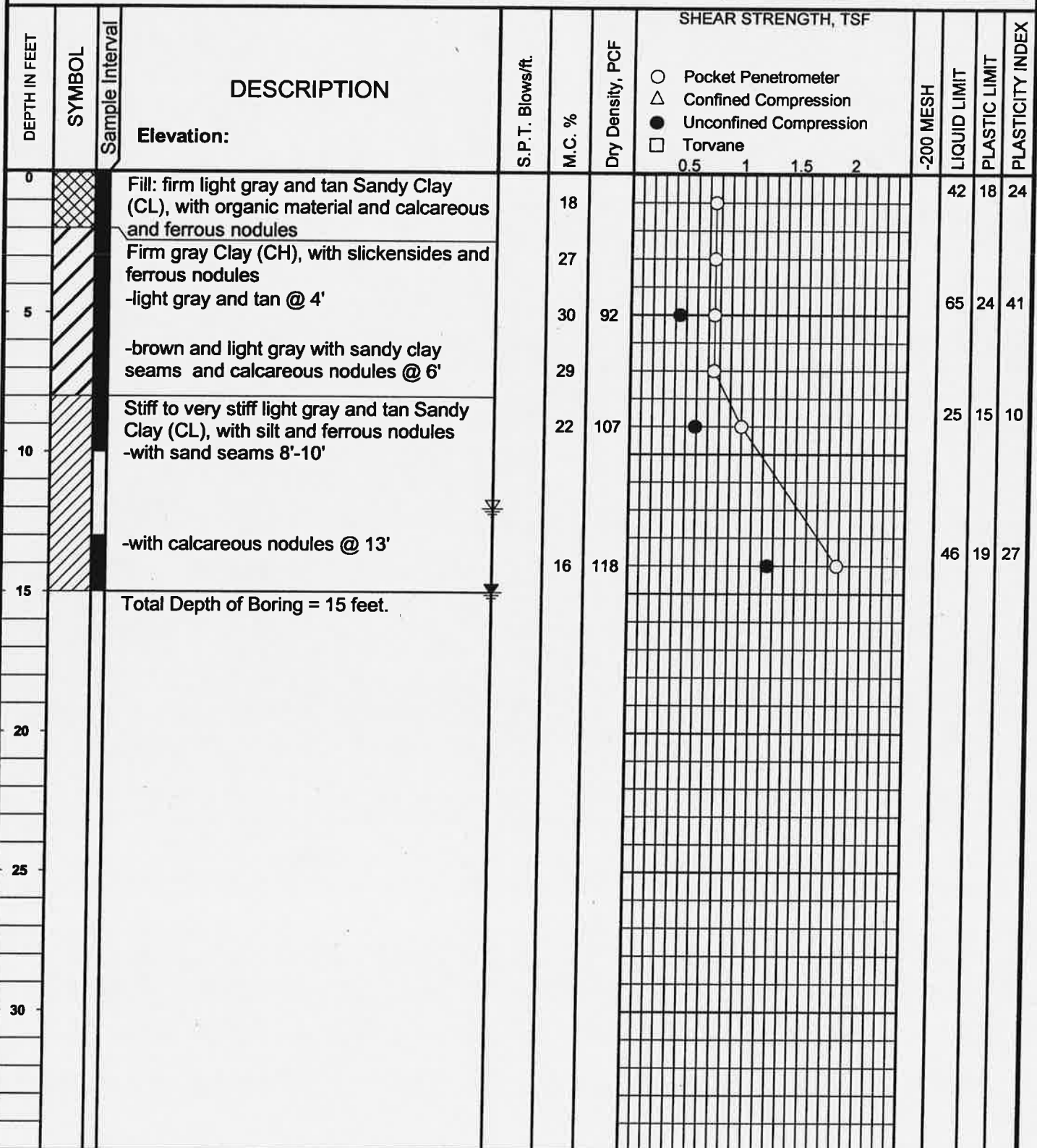
PROJECT: City of Houston Manhole Reconstruction

BORING B-14

DATE 01-20-04

TYPE 4" Auger

LOCATION See Boring Location Plan



BORING DRILLED TO 15 FEET WITHOUT DRILLING FLUID

WATER ENCOUNTERED AT 12 FEET WHILE DRILLING

WATER LEVEL AT 15 FEET AFTER 1/2 HOURS

DRILLED BY J.H. Drilling CHECKED BY Z.Y. LOGGED BY J.H. Drilling

PROJECT: City of Houston Manhole Reconstruction

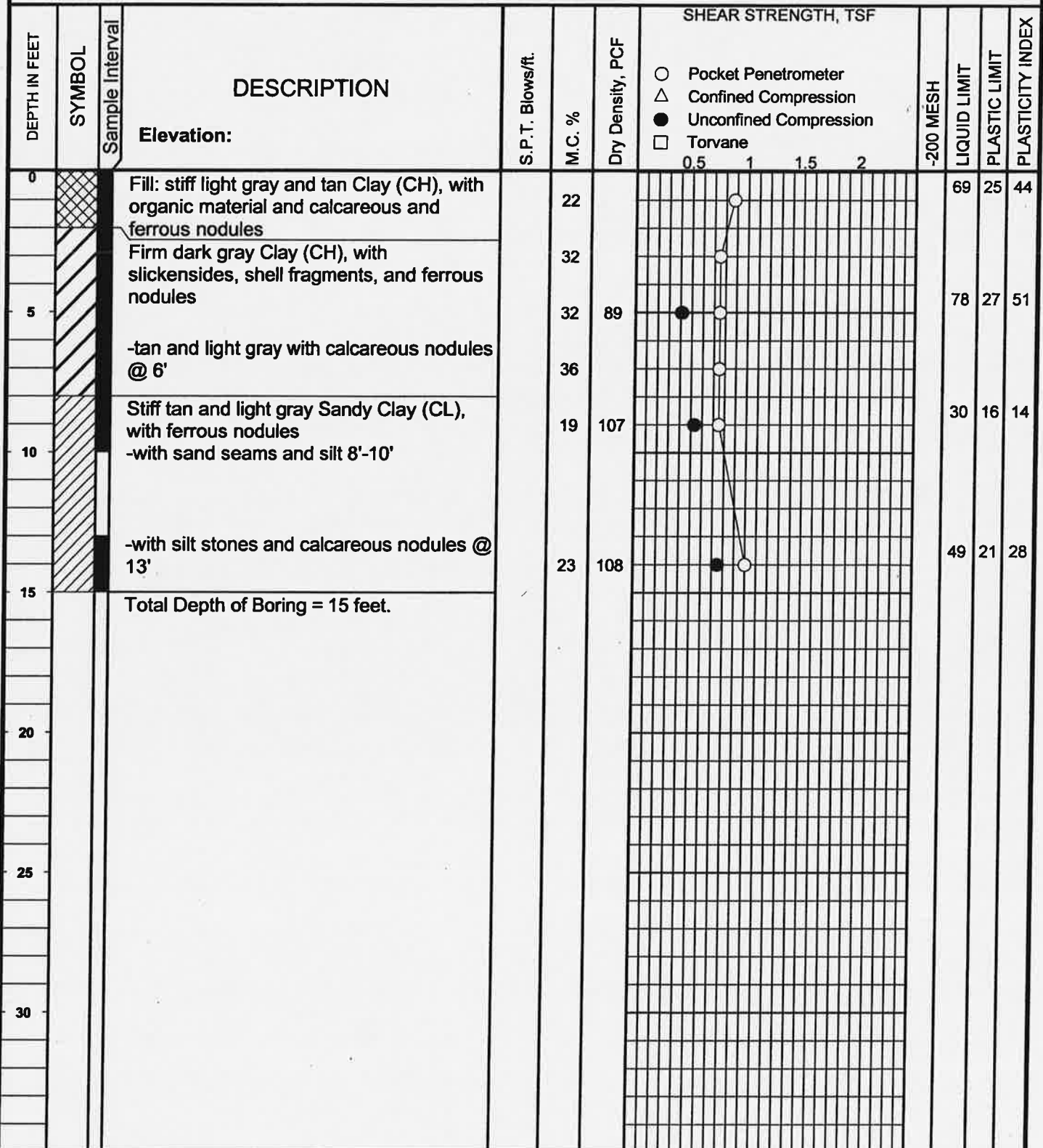
BORING

B-15

DATE 01-20-04

TYPE 4" Auger

LOCATION See Boring Location Plan



BORING DRILLED TO 15 FEET WITHOUT DRILLING FLUID

WATER ENCOUNTERED AT 0 FEET WHILE DRILLING

WATER LEVEL AT 0 FEET AFTER 0 HOURS

DRILLED BY J.H. Drilling CHECKED BY Z.Y. LOGGED BY J.H. Drilling

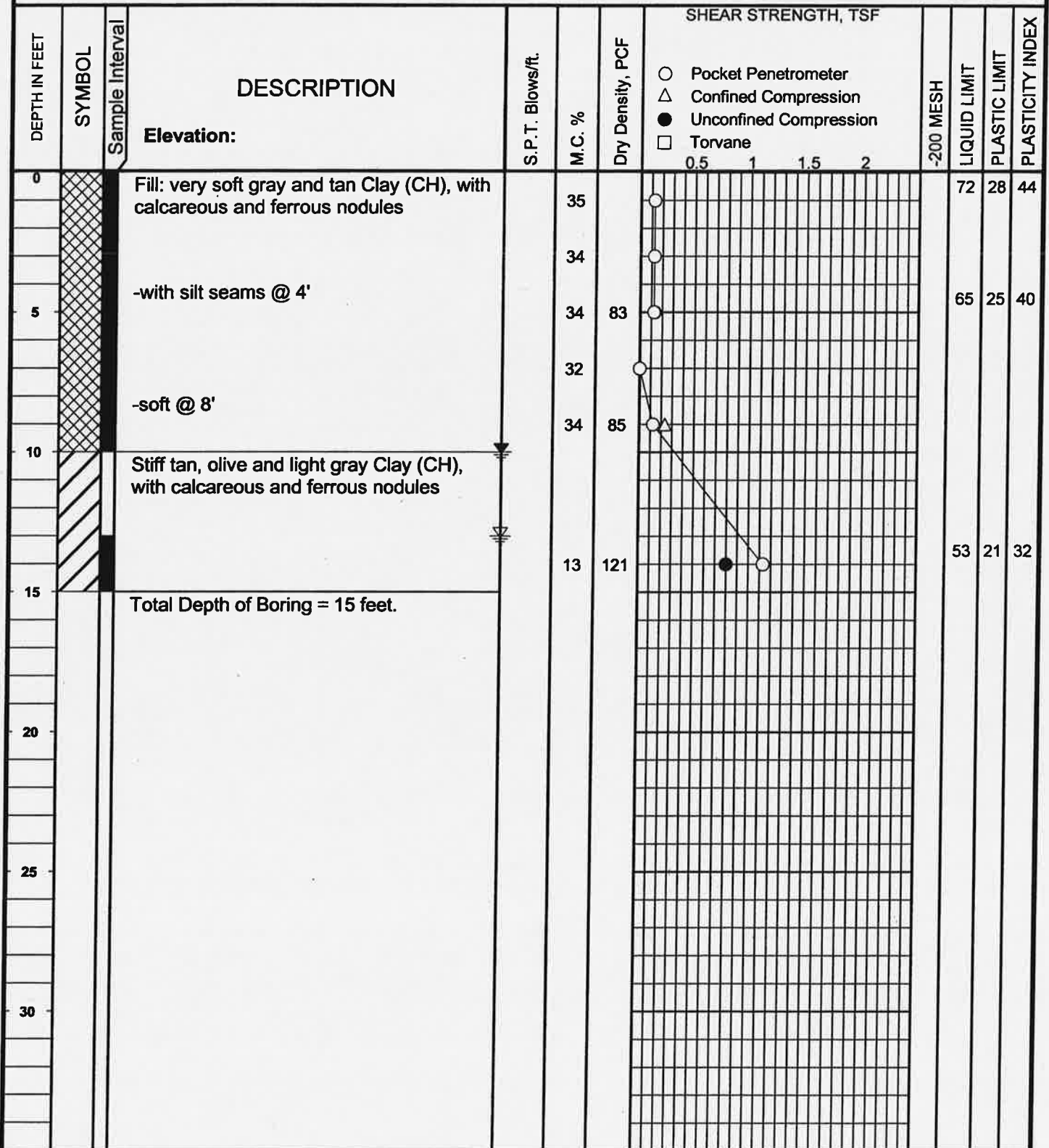
PROJECT: City of Houston Manhole Reconstruction

BORING B-16

DATE 01-20-04

TYPE 4" Auger

LOCATION See Boring Location Plan



BORING DRILLED TO 15 FEET WITHOUT DRILLING FLUID

WATER ENCOUNTERED AT 13 FEET WHILE DRILLING

WATER LEVEL AT 10 FEET AFTER 1/2 HOURS

DRILLED BY J.H. Drilling CHECKED BY Z.Y. LOGGED BY J.H. Drilling

PROJECT: City of Houston Manhole Reconstruction

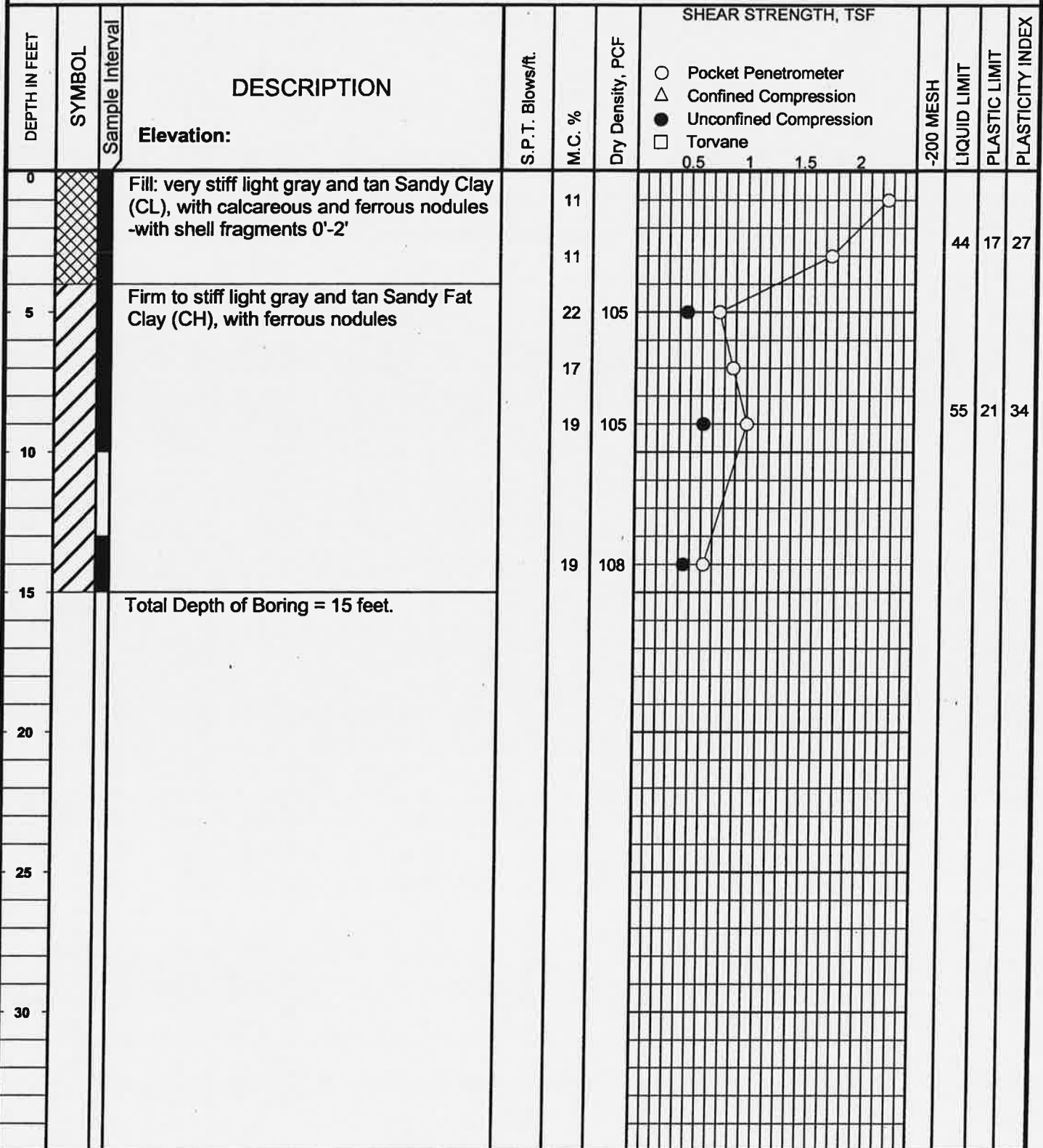
BORING

B-17

DATE 01-20-04

TYPE 4" Auger

LOCATION See Boring Location Plan



BORING DRILLED TO 15 FEET WITHOUT DRILLING FLUID

WATER ENCOUNTERED AT -- FEET WHILE DRILLING ≡

WATER LEVEL AT -- FEET AFTER -- HOURS ≡

DRILLED BY J.H. Drilling CHECKED BY Z.Y. LOGGED BY J.H. Drilling

KEY TO SYMBOLS

Symbol Description

Strata symbols



Fill



**Low plasticity
clay**



**High plasticity
clay**



Clayey sand



Silt



Silty sand



Paving

Soil Samplers



Shelby Tube sampler



Auger

ASTM DESIGNATION FOR SOIL LABORATORY TESTS

NAME OF TEST	ASTM TEST DESIGNATION
Moisture Content	D 2216
Specific Gravity	D 854
Sieve Analysis	D 421 D 422
Hydrometer Analysis	D 422
Minus No. 200 Sieve	D 1140
Liquid Limit	D 4318
Plastic Limit	D 4318
Shrinkage Limit	D 427
Standard Proctor Compaction	D 698
Modified Proctor Compaction	D 1557
Permeability (constant head)	D 2434
Consolidation	D 2435
Direct Shear	D 3080
Unconfined Compression	D 2166
Unconsolidated-Undrained Triaxial	D 2850
Consolidated-Undrained Triaxial	D 4767
California Bearing Ratio	D 1883
Unified Soil Classification System	D 2487

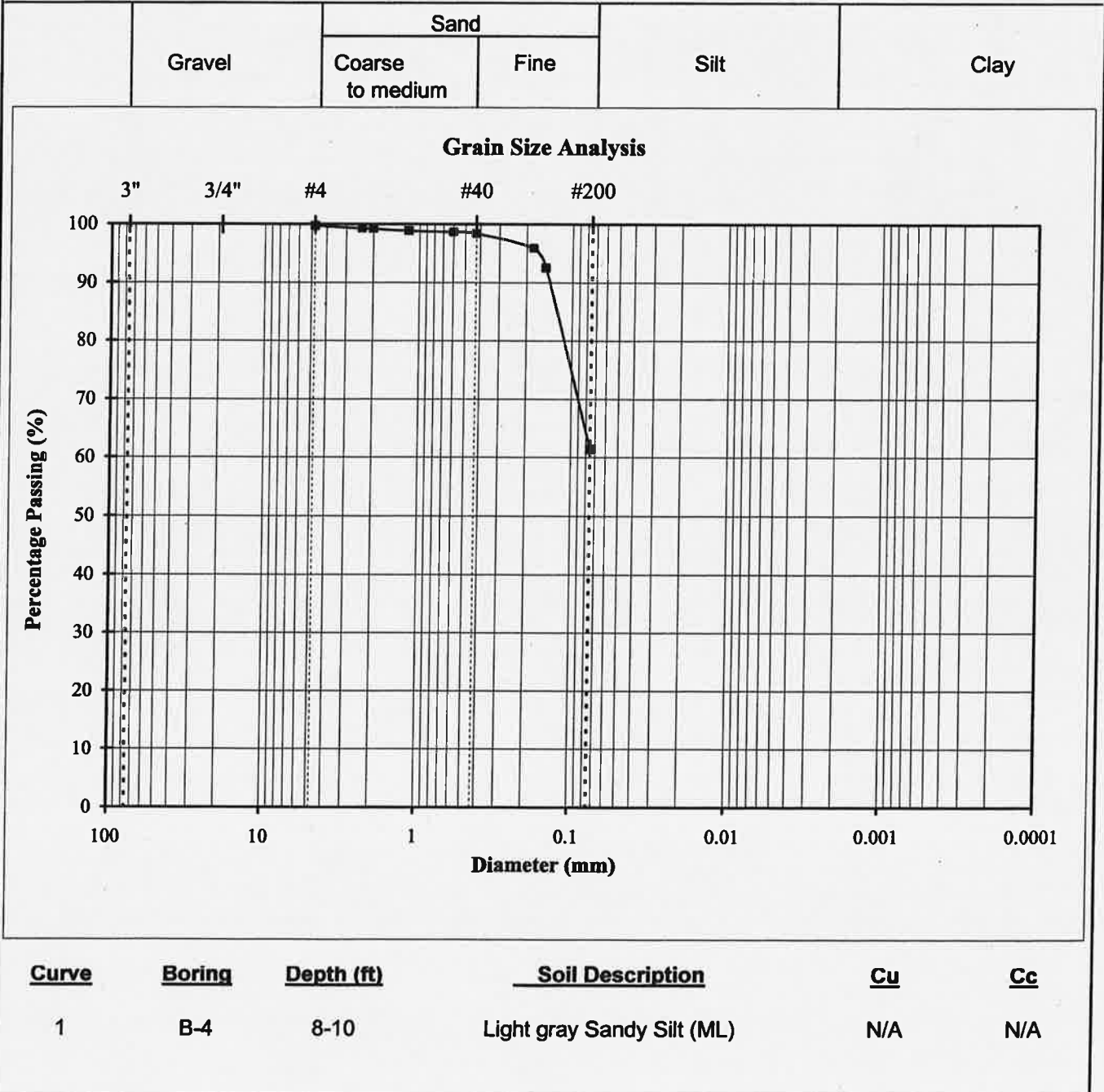
AVILES ENGINEERING CORPORATION

Consulting Engineers - Geotechnical, Construction Materials Testing, Environmental

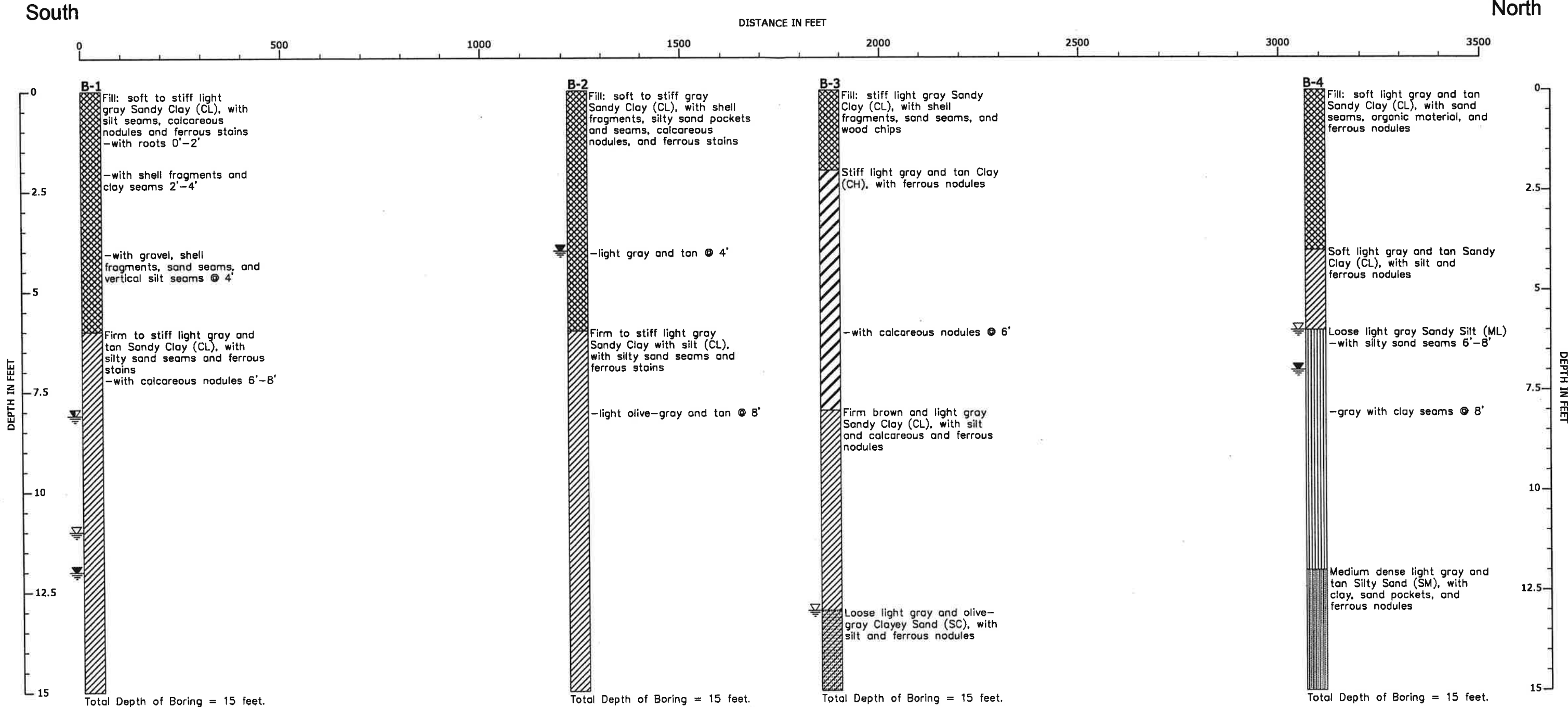
GRAIN SIZE ANALYSIS - SIEVE

Project : Air Valve and Manhole Reconstruction
Location of Project: Houston, Texas

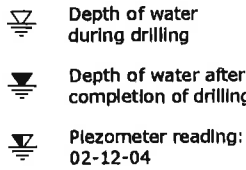
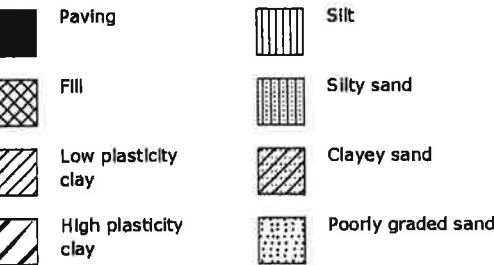
Job No.: G105-04
Date of Testing: 1/29/2004



GENERALIZED SUBSURFACE SOIL PROFILE



Legend:



- NOTES:
- 1) SOIL STRATIGRAPHY AND SECONDARY SOIL STRUCTURE (SUCH AS SEAMS, LAYERS, OR POCKETS OF SANDS, SILTS, SLICKENSIDES, AND FISSURES) THAT ARE DIFFERENT FROM WHAT WERE IDENTIFIED IN THE ACTUAL BORINGS MAY EXIST AWAY FROM THESE BORINGS.
- 2) ASSUMPTION: SURFACE ELEVATION AT ALL BORINGS IS THE SAME.
- 3) HORIZONTAL DISTANCES BETWEEN BORINGS ARE APPROXIMATE.

AVILES ENGINEERING CORPORATION

GENERALIZED SOIL PROFILE

AIR VALVES & MANHOLES RECONSTRUCTION
HOUSTON, TEXAS

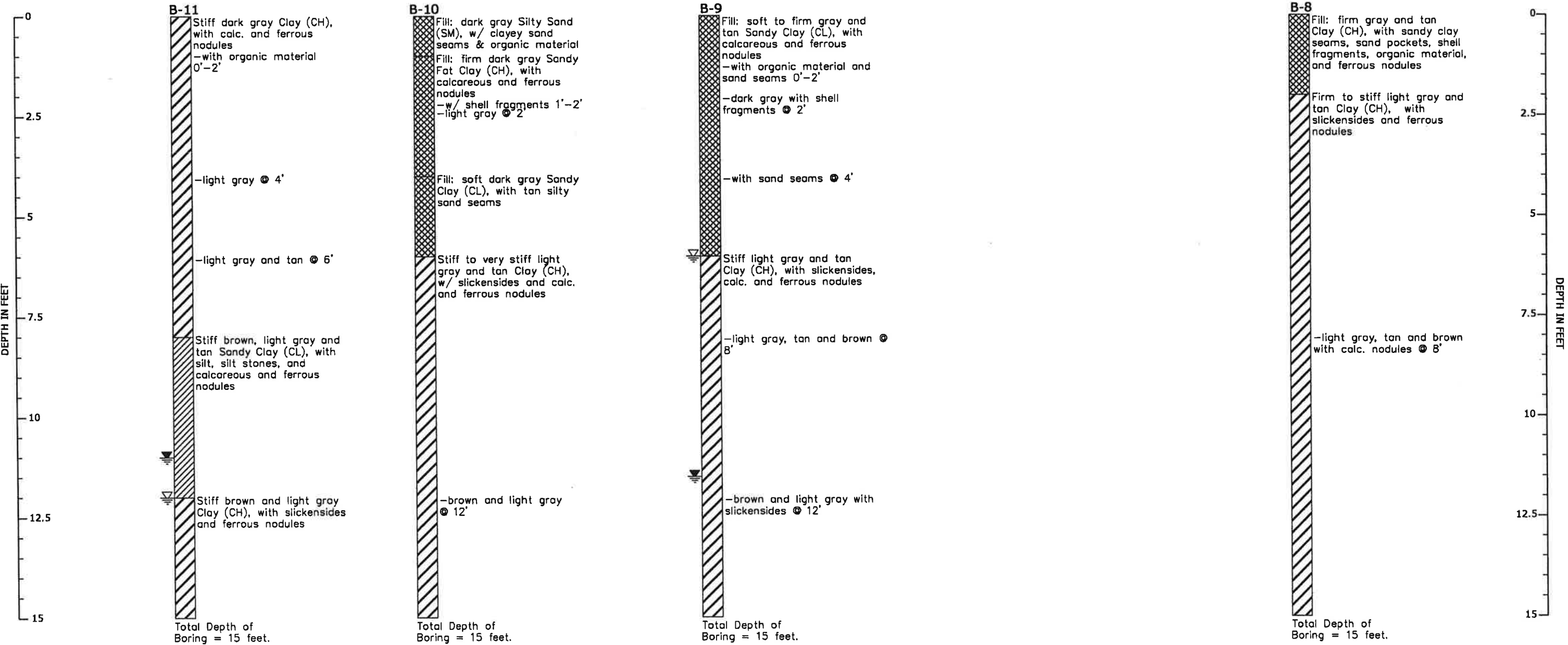
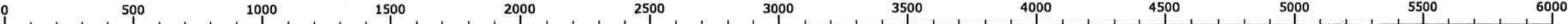
HORIZONTAL SCALE: 1" = 250'	AEC PROJECT NO.: G105-04	DATE: 02-19-03
VERTICAL SCALE: 1" = 2.5'	DRAWN BY: B.P.J.	PLATE NO.: PLATE A-22a

GENERALIZED SUBSURFACE SOIL PROFILE

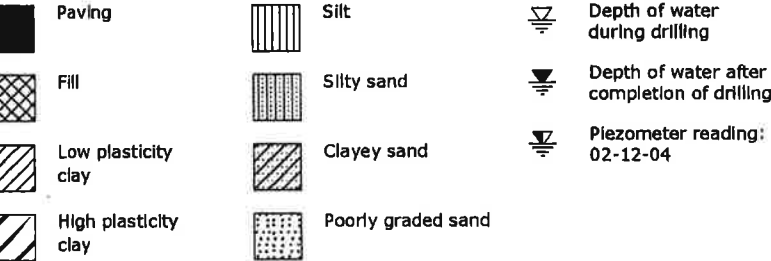
West

East

DISTANCE IN FEET



Legend:



- NOTES:
- 1) SOIL STRATIGRAPHY AND SECONDARY SOIL STRUCTURE (SUCH AS SEAMS, LAYERS, OR POCKETS OF SANDS, SILTS, SLICKENSIDES, AND FISSURES) THAT ARE DIFFERENT FROM WHAT WERE IDENTIFIED IN THE ACTUAL BORINGS MAY EXIST AWAY FROM THESE BORINGS.
 - 2) ASSUMPTION: SURFACE ELEVATION AT ALL BORINGS IS THE SAME.
 - 3) HORIZONTAL DISTANCES BETWEEN BORINGS ARE APPROXIMATE.

AVILES ENGINEERING CORPORATION

GENERALIZED SOIL PROFILE
AIR VALVES & MANHOLES RECONSTRUCTION
HOUSTON, TEXAS

HORIZONTAL SCALE: 1" = 500'	AEC PROJECT NO.: G105-04	DATE: 02-19-03
VERTICAL SCALE: 1" = 2.5'	DRAWN BY: B.P.J.	PLATE NO.: PLATE A-22b

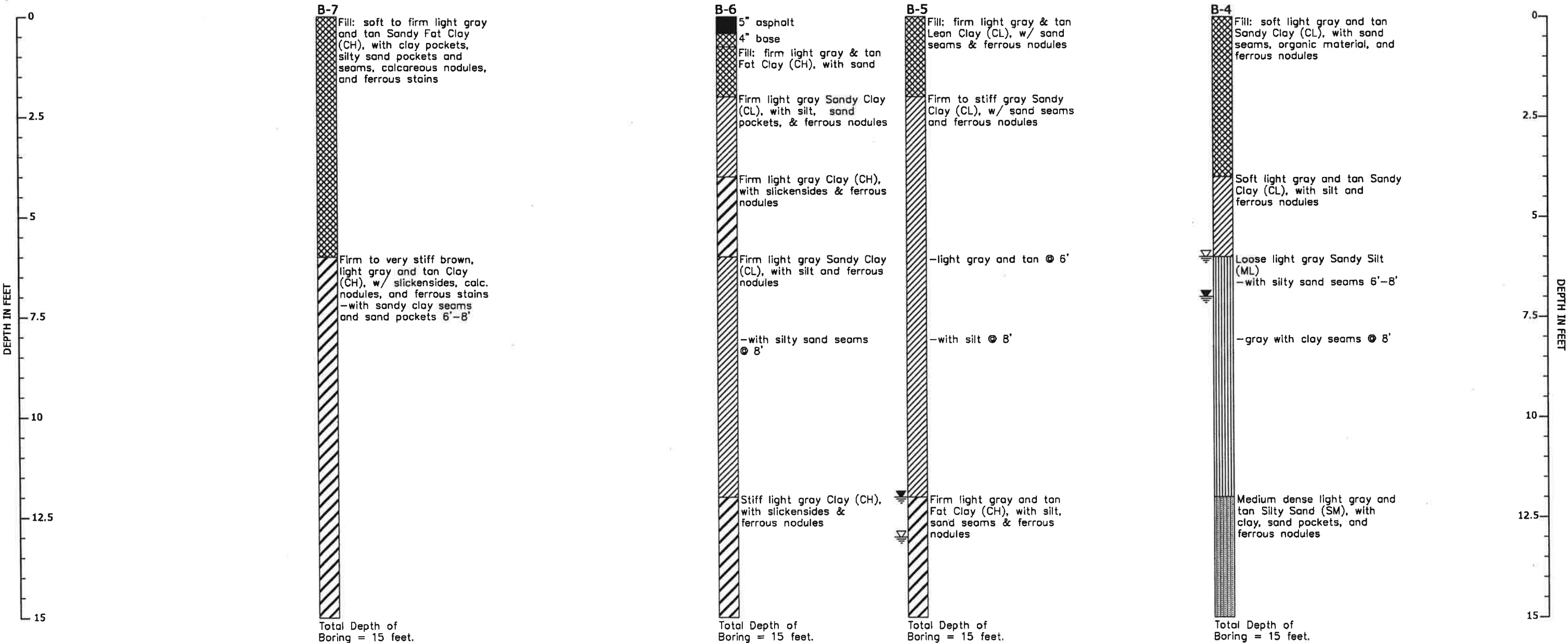
GENERALIZED SUBSURFACE SOIL PROFILE

West

East

DISTANCE IN FEET

7500 8000 8500 9000 9500 10000 10500 11000 11500 12000 12500 13000 13500



Legend:

- | | | | |
|--|----------------------|--|--------------------|
| | Paving | | Silt |
| | Fill | | Silty sand |
| | Low plasticity clay | | Clayey sand |
| | High plasticity clay | | Poorly graded sand |

- Depth of water during drilling
- Depth of water after completion of drilling
- Piezometer reading: 02-12-04

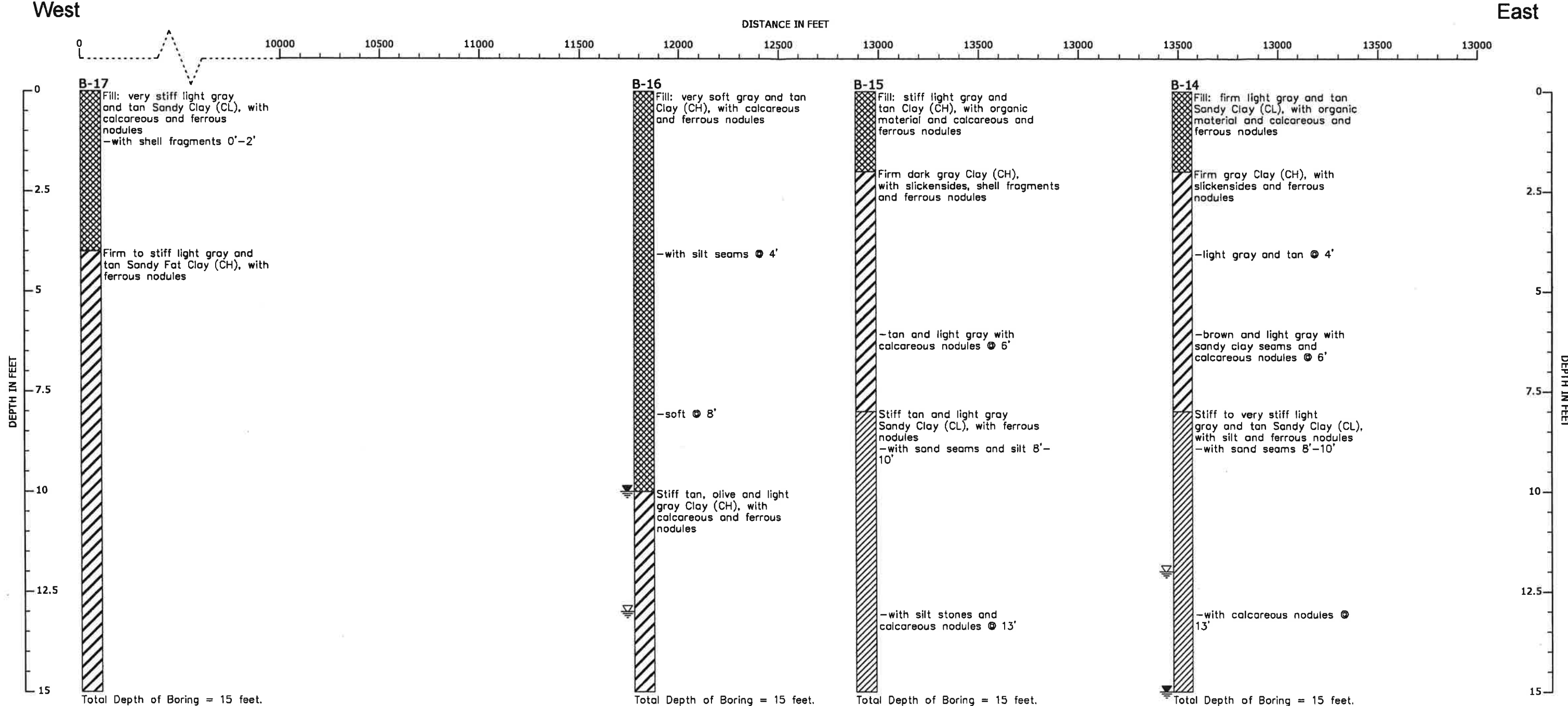
- NOTES:
- 1) SOIL STRATIGRAPHY AND SECONDARY SOIL STRUCTURE (SUCH AS SEAMS, LAYERS, OR POCKETS OF SANDS, SILTS, SLICKENSIDES, AND FISSURES) THAT ARE DIFFERENT FROM WHAT WERE IDENTIFIED IN THE ACTUAL BORINGS MAY EXIST AWAY FROM THESE BORINGS.
 - 2) ASSUMPTION: SURFACE ELEVATION AT ALL BORINGS IS THE SAME.
 - 3) HORIZONTAL DISTANCES BETWEEN BORINGS ARE APPROXIMATE.

AVILES ENGINEERING CORPORATION

GENERALIZED SOIL PROFILE
AIR VALVES & MANHOLES RECONSTRUCTION
HOUSTON, TEXAS

HORIZONTAL SCALE: 1" = 500'	AEC PROJECT NO.: G105-04	DATE: 02-19-03
VERTICAL SCALE: 1" = 2.5'	DRAWN BY: B.P.J.	PLATE NO.: PLATE A-22c

GENERALIZED SUBSURFACE SOIL PROFILE



Legend:

Paving

Fill

Low plasticity clay

High plasticity clay

Silt

Silty sand

Clayey sand

Poorly graded sand

Depth of water during drilling

Depth of water after completion of drilling

Piezometer reading: 02-12-04

- NOTES:
- 1) SOIL STRATIGRAPHY AND SECONDARY SOIL STRUCTURE (SUCH AS SEAMS, LAYERS, OR POCKETS OF SANDS, SILTS, SLICKENSIDES, AND FISSURES) THAT ARE DIFFERENT FROM WHAT WERE IDENTIFIED IN THE ACTUAL BORINGS MAY EXIST AWAY FROM THESE BORINGS.
 - 2) ASSUMPTION: SURFACE ELEVATION AT ALL BORINGS IS THE SAME.
 - 3) HORIZONTAL DISTANCES BETWEEN BORINGS ARE APPROXIMATE.

AVILES ENGINEERING CORPORATION

GENERALIZED SOIL PROFILE

AIR VALVES & MANHOLES RECONSTRUCTION

HOUSTON, TEXAS

HORIZONTAL SCALE: 1" = 500'	AEC PROJECT NO.: G105-04	DATE: 02-19-03
VERTICAL SCALE: 1" = 2.5'	DRAWN BY: B.P.J.	PLATE NO.: PLATE A-22d

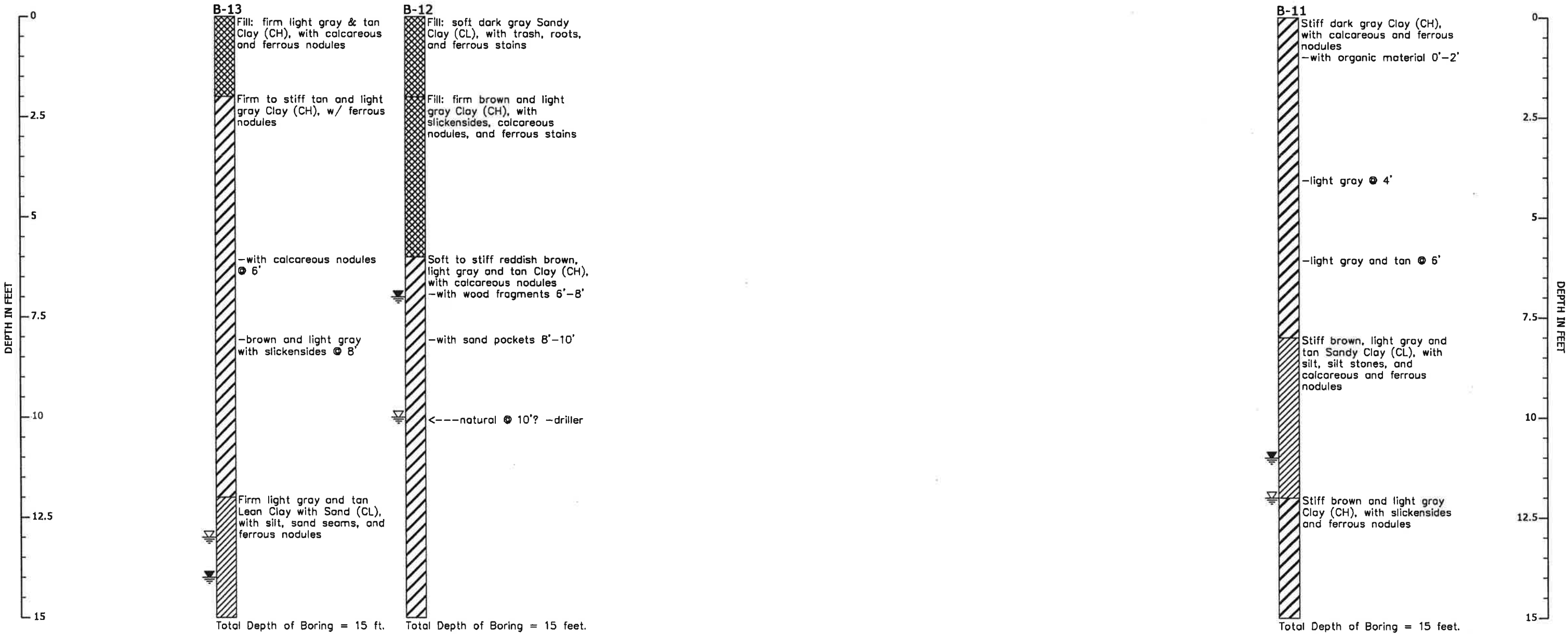
GENERALIZED SUBSURFACE SOIL PROFILE

West

East

DISTANCE IN FEET

20000 20500 21000 21500 22000 22500 23000 23500 24000 24500 25000 25500 26000



Legend:

	Paving		Silt		Depth of water during drilling
	Fill		Silty sand		Depth of water after completion of drilling
	Low plasticity clay		Clayey sand		Piezometer reading: 02-12-04
	High plasticity clay		Poorly graded sand		

NOTES:

- 1) SOIL STRATIGRAPHY AND SECONDARY SOIL STRUCTURE (SUCH AS SEAMS, LAYERS, OR POCKETS OF SANDS, SILTS, SLICKENSIDES, AND FISSURES) THAT ARE DIFFERENT FROM WHAT WERE IDENTIFIED IN THE ACTUAL BORINGS MAY EXIST AWAY FROM THESE BORINGS.
- 2) ASSUMPTION: SURFACE ELEVATION AT ALL BORINGS IS THE SAME.
- 3) HORIZONTAL DISTANCES BETWEEN BORINGS ARE APPROXIMATE.

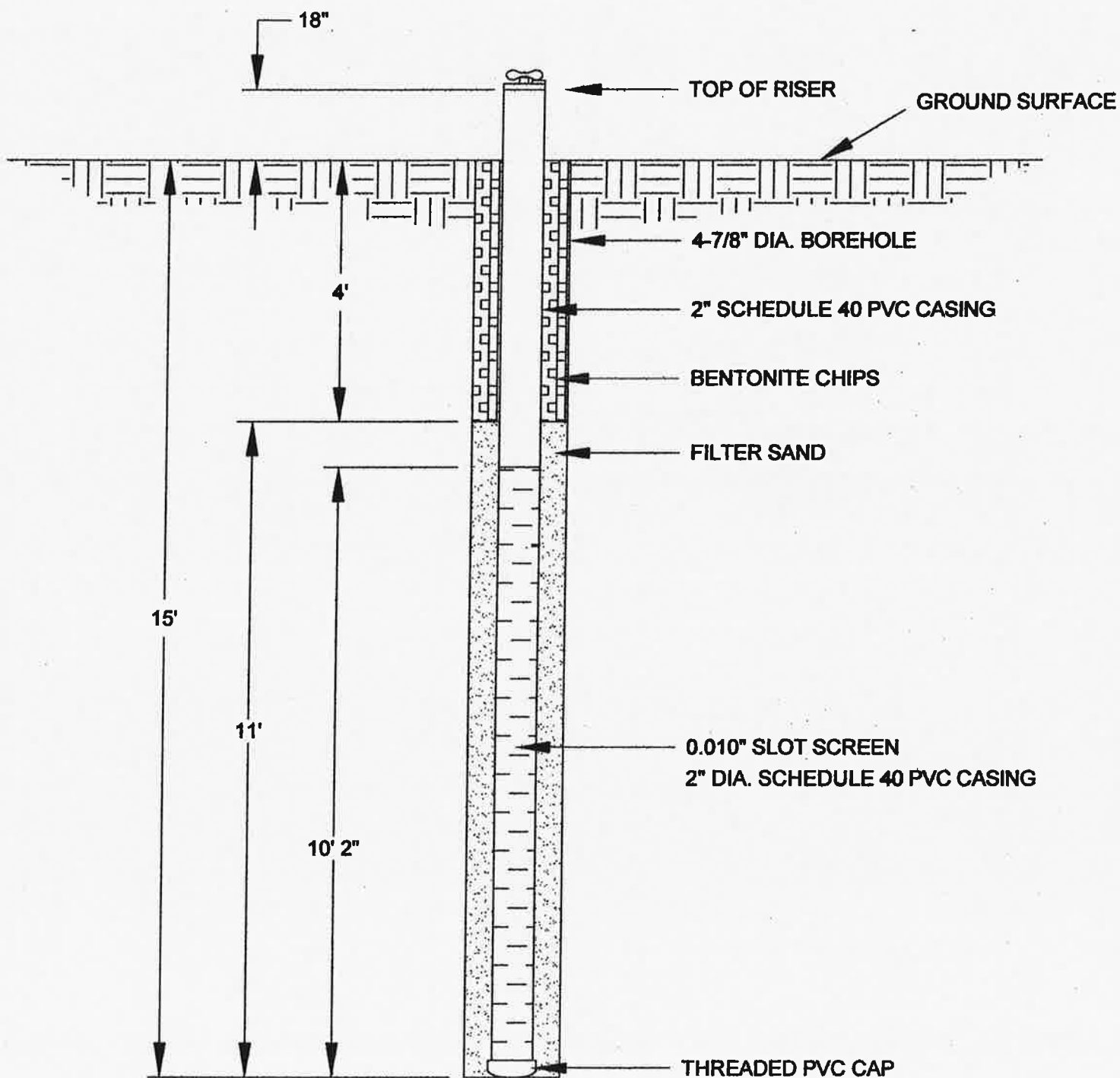
AVILES ENGINEERING CORPORATION

GENERALIZED SOIL PROFILE AIR VALVES & MANHOLES RECONSTRUCTION HOUSTON, TEXAS

HORIZONTAL SCALE 1" = 500'	AEC PROJECT NO.: G105-04	DATE 02-19-03
VERTICAL SCALE 1" = 2.5'	DRAWN BY: B.P.J.	PLATE NO.: PLATE A-22e

APPENDIX B

Plates B-1 thru B-7 Piezometer Installation Details



PIEZOMETRIC LEVEL:
(FEET) FROM
GROUND SURFACE

6.6

DATE

02-12-04

AVILES ENGINEERING CORPORATION

PIEZOMETER INSTALLATION DETAIL
BORING NO. B-1

AIR VALVES & MANHOLES RECONSTRUCTION
HOUSTON, TEXAS

AEC PROJECT NO.:

G105-04

DATE

02-19-04

SOURCE DWG. BY:

AVILES ENGINEERING CORP.

SCALE:

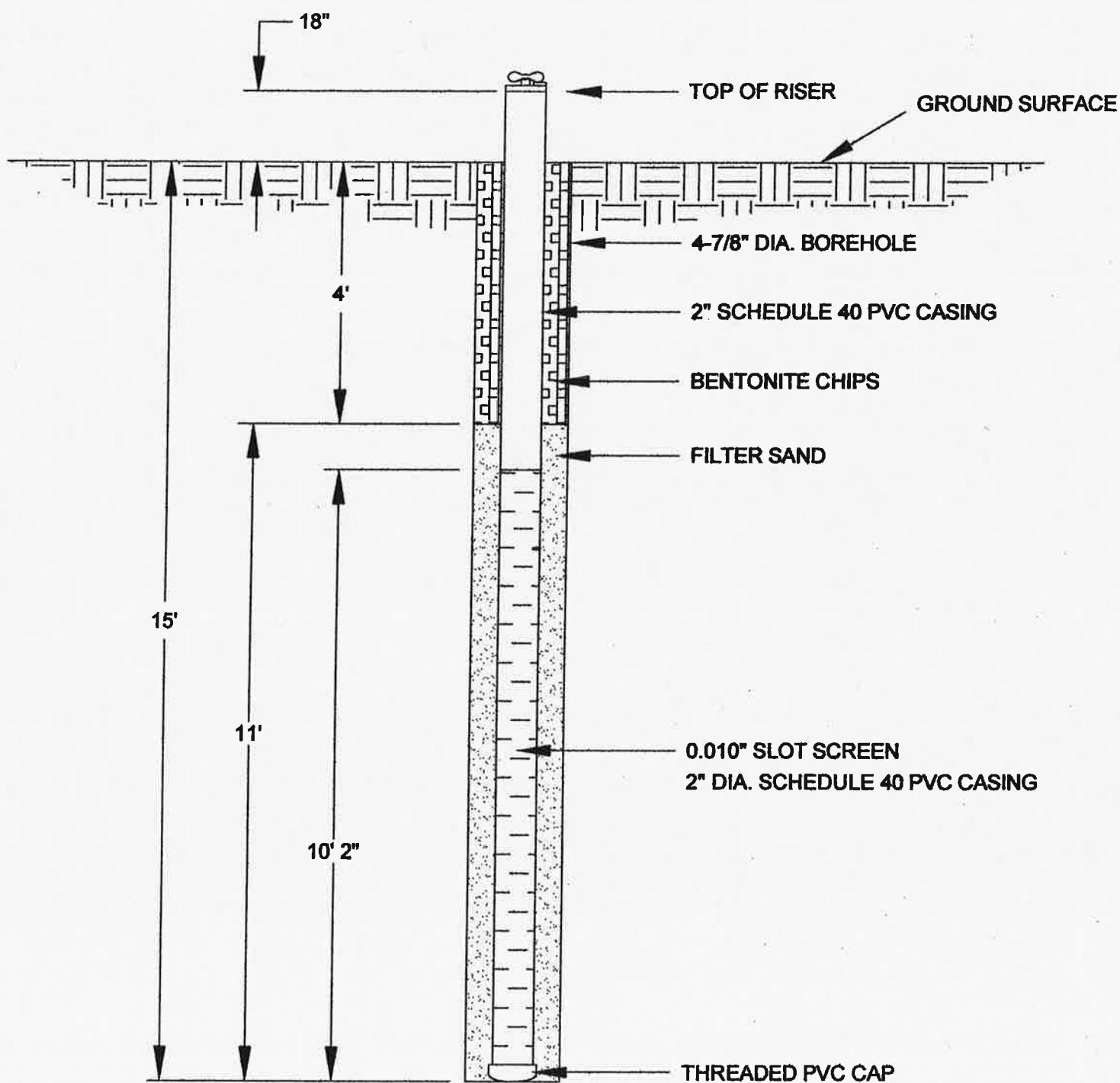
N.T.S.

DRAWN BY:

B.P.J.

PLATE NO.:

PLATE B-1

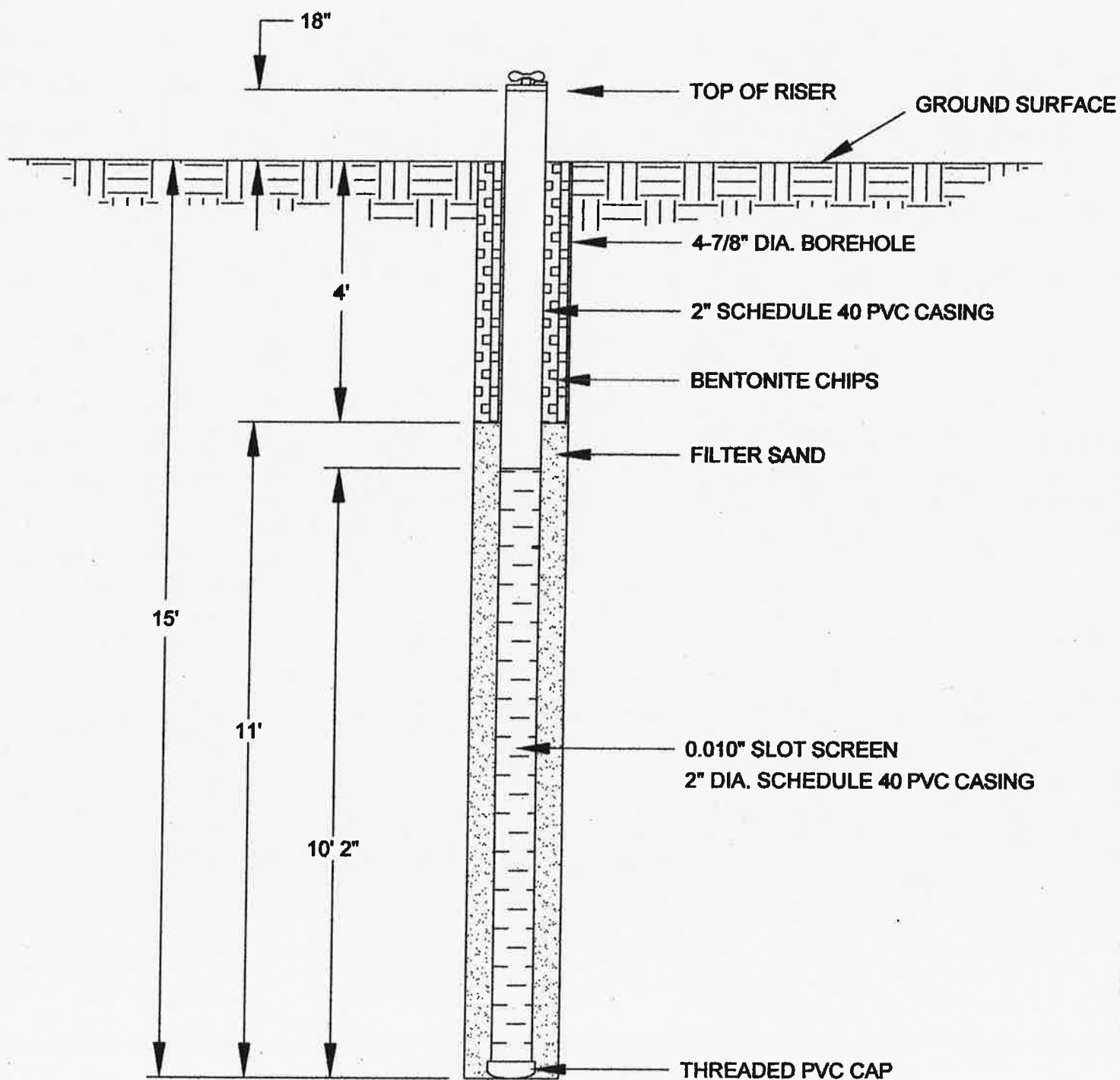


AVILES ENGINEERING CORPORATION

PIEZOMETER INSTALLATION DETAIL BORING NO. B-5

AIR VALVES & MANHOLES RECONSTRUCTION
HOUSTON, TEXAS

AEC PROJECT NO.:	DATE:	SOURCE DWG. BY:
G105-04	02-19-04	AVILES ENGINEERING CORP.
SCALE:	DRAWN BY:	PLATE NO.:
N.T.S.	B.P.J.	PLATE B-2



AVILES ENGINEERING CORPORATION

PIEZOMETER INSTALLATION DETAIL
BORING NO. B-8

AIR VALVES & MANHOLES RECONSTRUCTION
HOUSTON, TEXAS

ABO PROJECT NO.:
G105-04

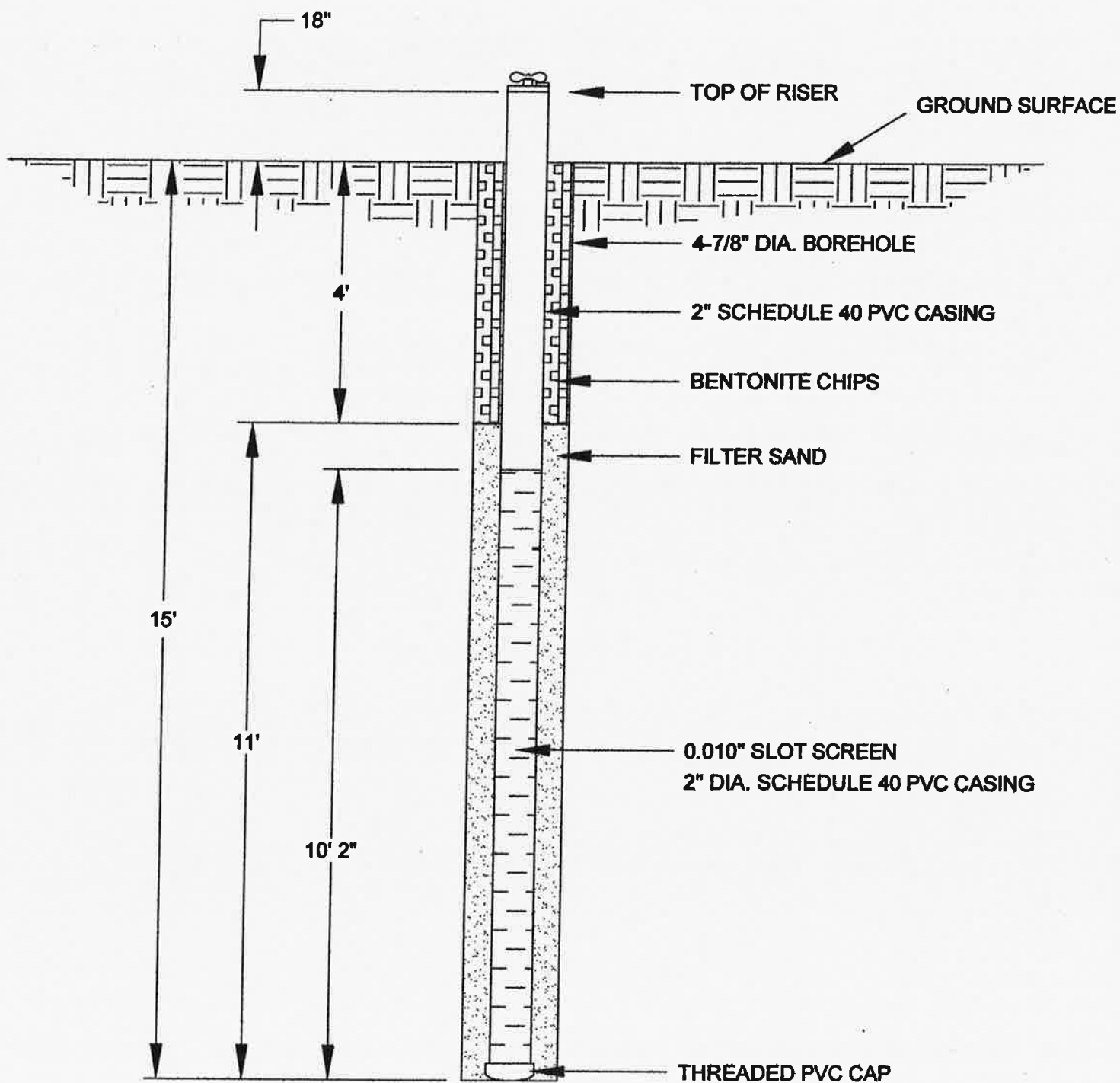
DATE
02-19-04

SOURCE DWG. BY:
AVILES ENGINEERING CORP.

SCALE:
N.T.S.

DRAWN BY:
B.P.J.

PLATE NO.:
PLATE B-3



PIEZOMETRIC LEVEL:
(FEET) FROM
GROUND SURFACE

2.5

DATE

02-12-04

AVILES ENGINEERING CORPORATION

PIEZOMETER INSTALLATION DETAIL
BORING NO. B-10

AIR VALVES & MANHOLES RECONSTRUCTION
HOUSTON, TEXAS

ABC PROJECT NO.:

G105-04

DATE:

02-19-04

SOURCE DWG. BY:

AVILES ENGINEERING CORP.

SCALE:

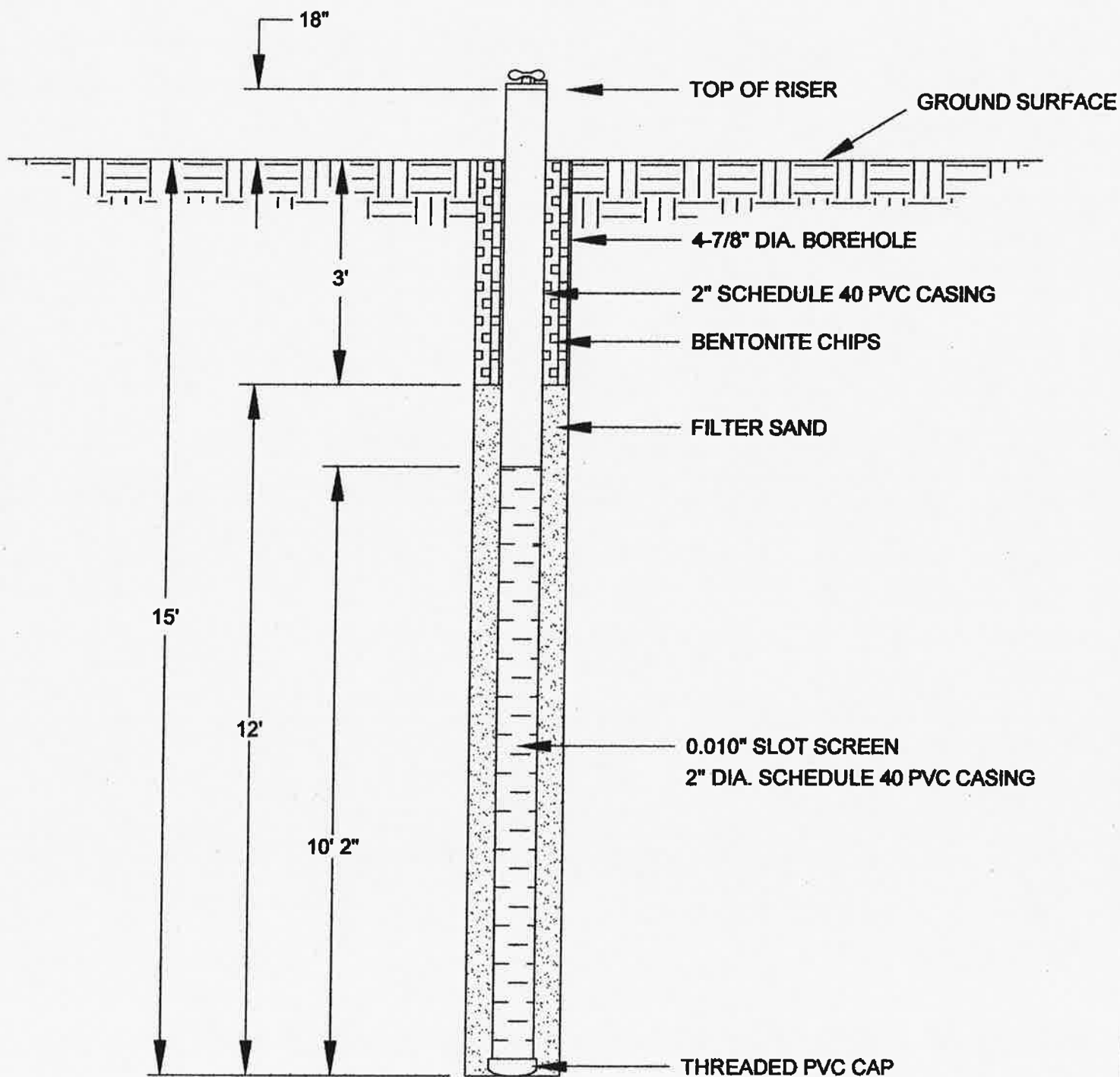
N.T.S.

DRAWN BY:

B.P.J.

PLATE NO.:

PLATE B-4



PIEZOMETRIC LEVEL:
(FEET) FROM
GROUND SURFACE

3.0

DATE

02-12-04

AVILES ENGINEERING CORPORATION

PIEZOMETER INSTALLATION DETAIL BORING NO. B-12

AIR VALVES & MANHOLES RECONSTRUCTION
HOUSTON, TEXAS

AEC PROJECT NO.:

G105-04

DATE:

02-19-04

SOURCE DWG. BY:

AVILES ENGINEERING CORP.

SCALE:

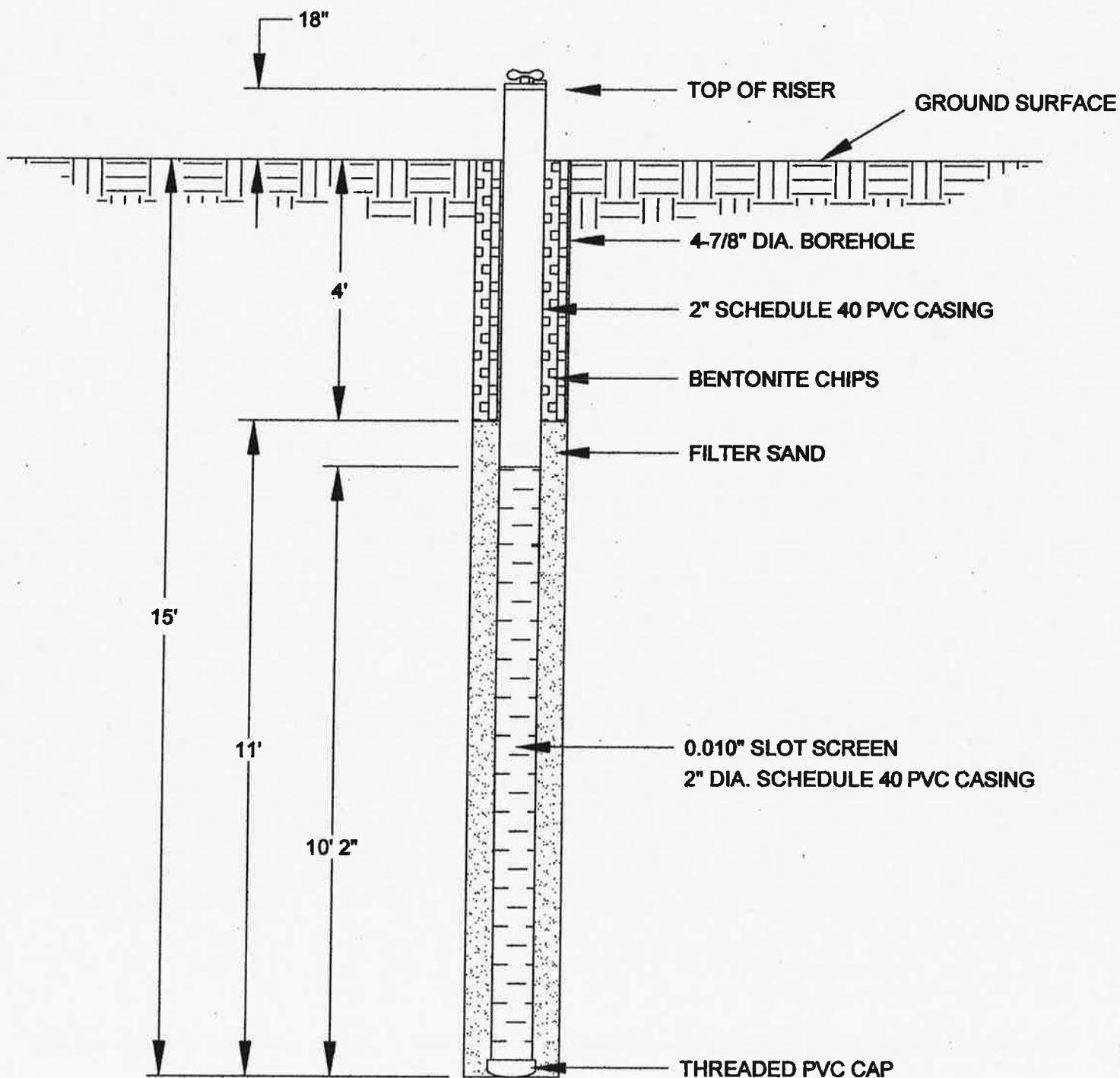
N.T.S.

DRAWN BY:

B.P.J.

PLATE NO.:

PLATE B-5



PIEZOMETRIC LEVEL:
(FEET) FROM
GROUND SURFACE

8.0

DATE

02-12-04

AVILES ENGINEERING CORPORATION

PIEZOMETER INSTALLATION DETAIL
BORING NO. B-15

AIR VALVES & MANHOLES RECONSTRUCTION
HOUSTON, TEXAS

AEO PROJECT NO.:

G105-04

DATE:

02-19-04

SOURCE DWG. BY:

AVILES ENGINEERING CORP.

SCALE:

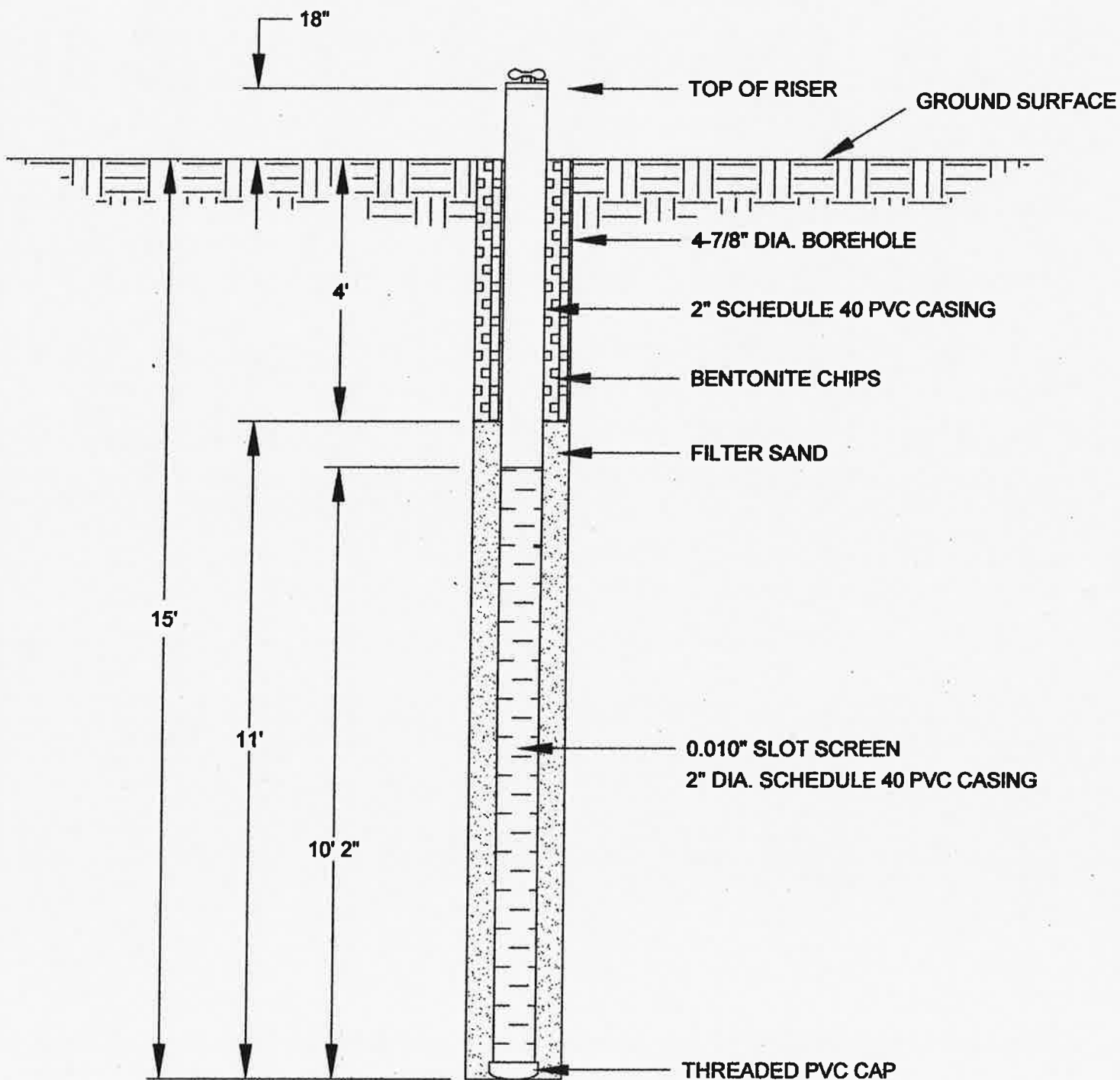
N.T.S.

DRAWN BY:

B.P.J.

PLATE NO.:

PLATE B-6



PIEZOMETRIC LEVEL:
(FEET) FROM
GROUND SURFACE

4.3

DATE

02-12-04

AVILES ENGINEERING CORPORATION

PIEZOMETER INSTALLATION DETAIL
BORING NO. B-17

AIR VALVES & MANHOLES RECONSTRUCTION
HOUSTON, TEXAS

AEC PROJECT NO.:

G105-04

DATE:

02-19-04

SOURCE DWG. BY:

AVILES ENGINEERING CORP.

SCALE:

N.T.S.

DRAWN BY:

B.P.J.

PLATE NO.:

PLATE B-7

APPENDIX C

Plate C-1 OSHA Soil Classification for Excavation Trenching and Shoring

OSHA SOIL CLASSIFICATION FOR EXCAVATING, TRENCHING AND SHORING

BORING NO.	0-5'	5'-10'	10'-15'
B-1	C	C	B
B-2	C	C	B
B-3	C	B	B
B-4	C	C	C
B-5	C	B	B
B-6	C	B	C
B-7	C	C	C
B-8	C	C	C
B-9	C	C	C
B-10	C	C	C
B-11	B	B	B
B-12	C	C	C
B-13	C	B	B
B-14	C	C	B
B-15	C	C	B
B-16	C	C	B
B-17	C	B	B

Soil Type Criteria

A: $q_u = 1.5$ tsf or greater

B: $q_u = 0.5$ tsf or greater

C: $q_u =$ Less than 0.5 tsf or granular soils

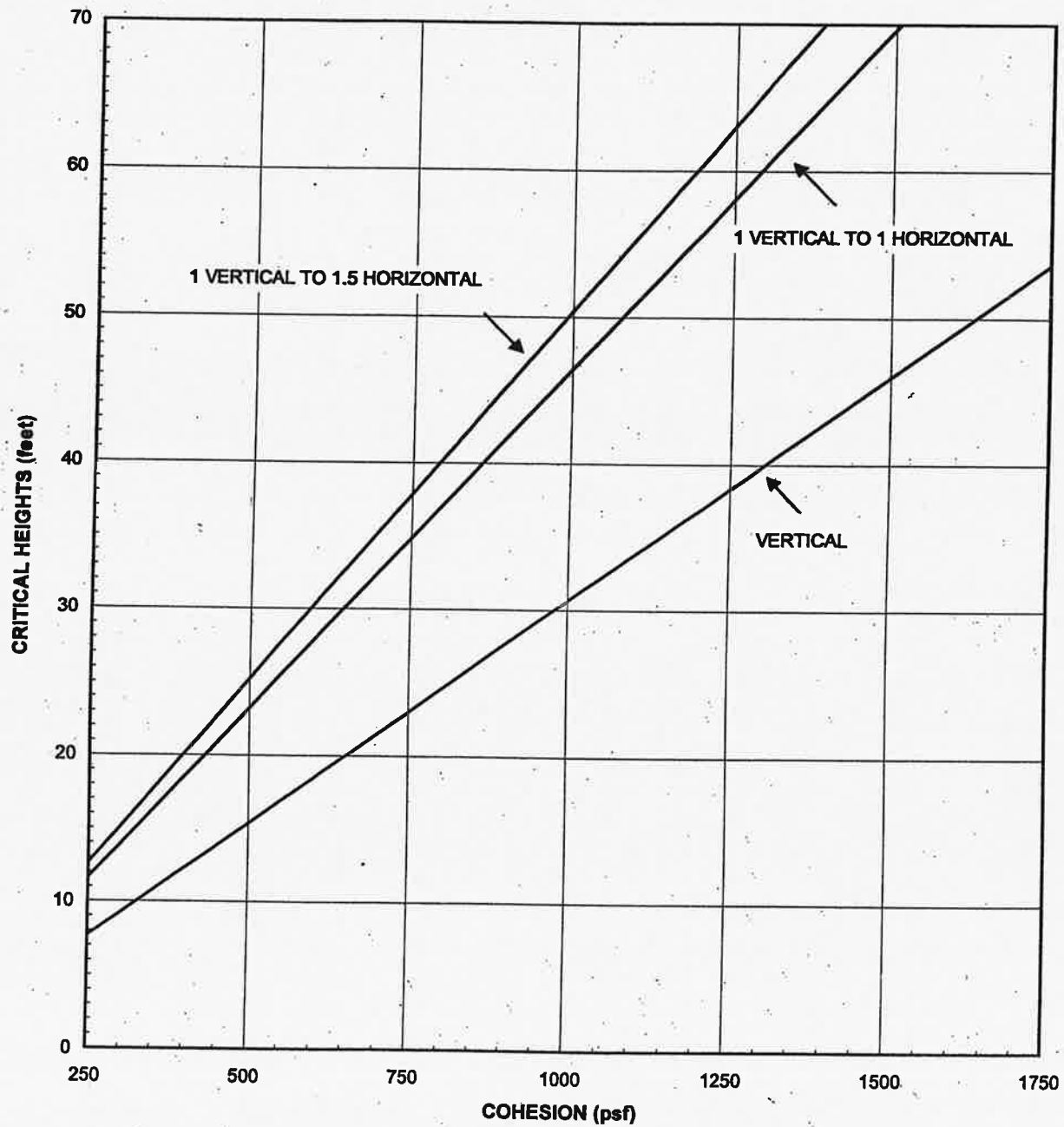
Note: $q_u =$ Unconfined Compressive Strength in tsf

Soil classifications shown in the above table represent conditions encountered during drilling and sampling.

Conditions may be different during construction, possibly resulting in changed soil classifications.

APPENDIX D

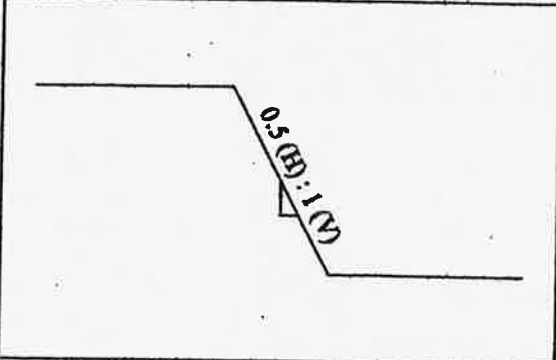
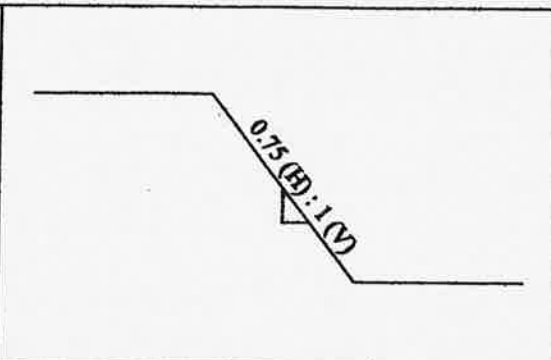
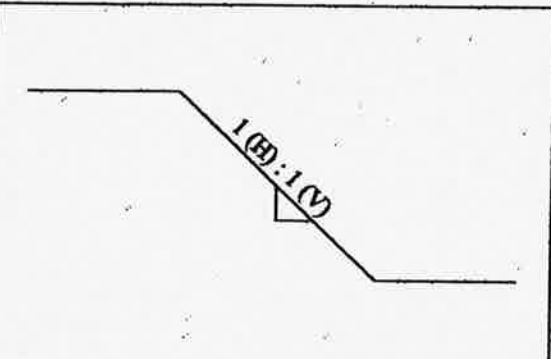
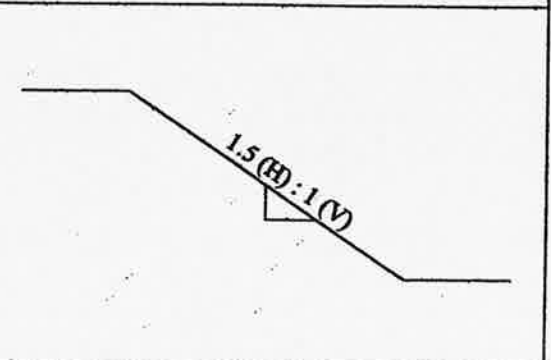
Plate D-1	Critical Heights
Plate D-2	Maximum Allowable Slopes
Plate D-3	A Combination of Bracing and Open Cut
Plate D-4	Logarithmic Spiral Method For Calculating Earth Pressure Against Bracing
Plate D-5	Lateral Pressure Diagrams - For Open Cuts in Cohesive Soils - Long Term Conditions
Plate D-6	Lateral Pressure Diagrams - For Open Cuts in Cohesive Soils - Short Term Conditions
Plate D-7	Lateral Pressure Diagrams - For Open Cuts in Sand - Long Term Conditions
Plate D-8	Lateral Pressure Diagrams - For Open Cuts in Sand - Short Term Conditions
Plate D-9	Bottom Stability for Braced Excavation
Plate D-10	Uplift Pressure and Resistance



CRITICAL HEIGHTS OF CUTS IN NONFISSURED CLAYS

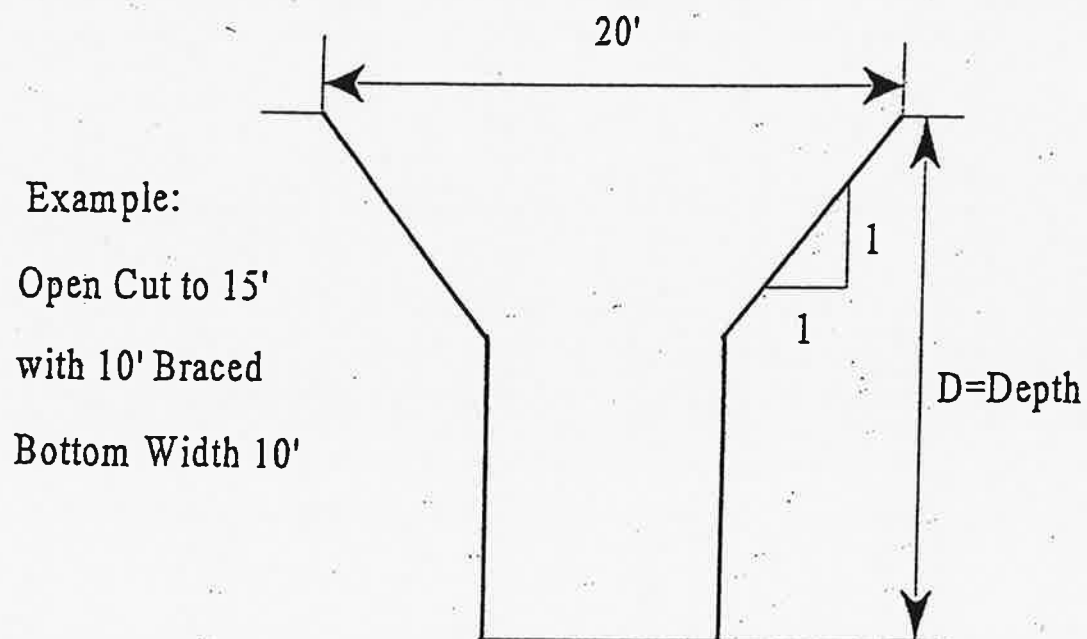
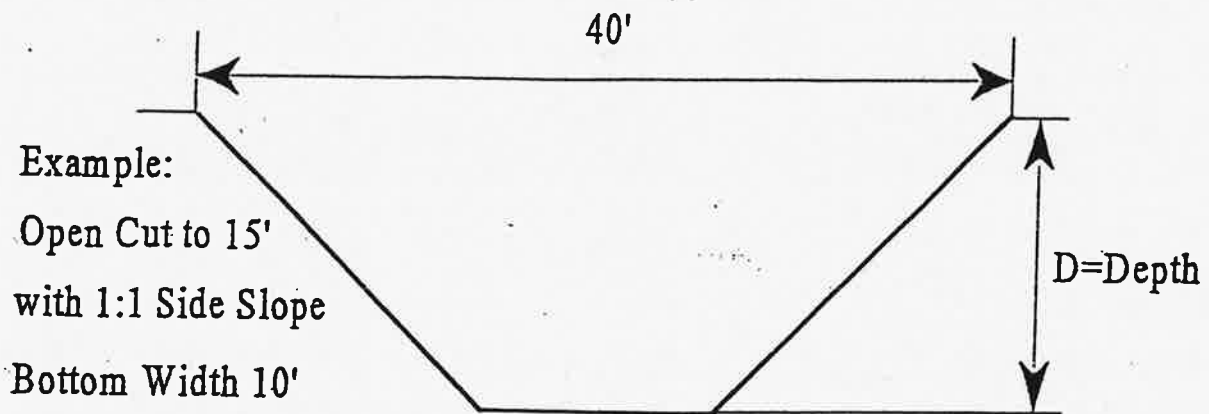
Note: The charts are calculated based on NAVFAC DM-7.1, Page 7.1-319, assuming the critical circles are toe circles, and wet unit weight of soils = 125 pcf.

MAXIMUM ALLOWABLE SLOPES

TYPE A		
TYPE B		
TYPE C		
	Short Term	Long Term

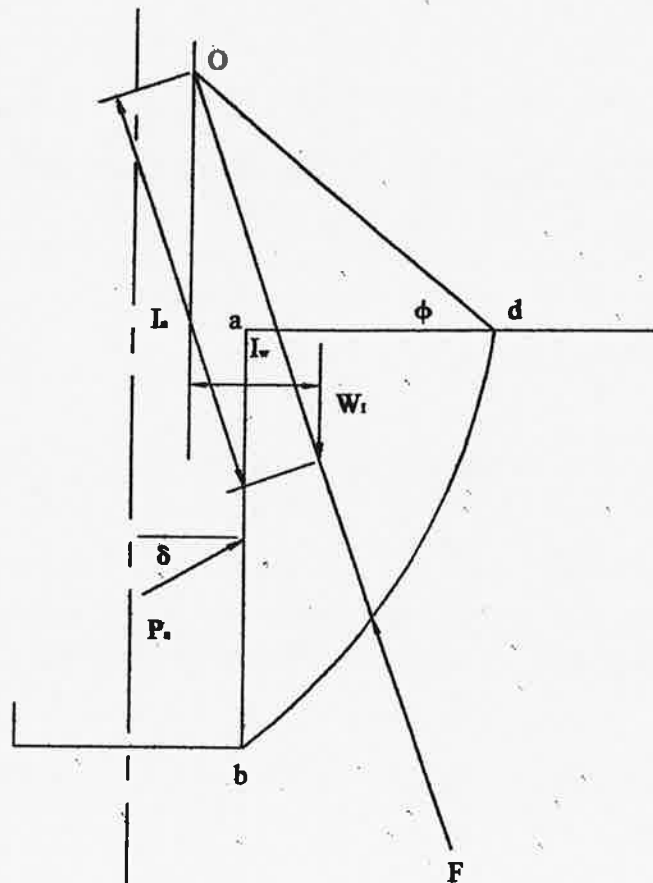
A short term maximum allowable slope of $\frac{1}{2}$ (H) : 1(V) is allowed in excavations that are 12 feet or less in depth. Short term maximum allowable slopes for excavations greater than 12 feet in depth shall be $\frac{3}{4}$ (H) : 1(V).

Note: Maximum depth for above trench is 20 feet. For trench deeper than 20 feet, the trench protection should be designed by the Contractor's professional engineer.



A COMBINATION OF BRACING AND OPEN CUT

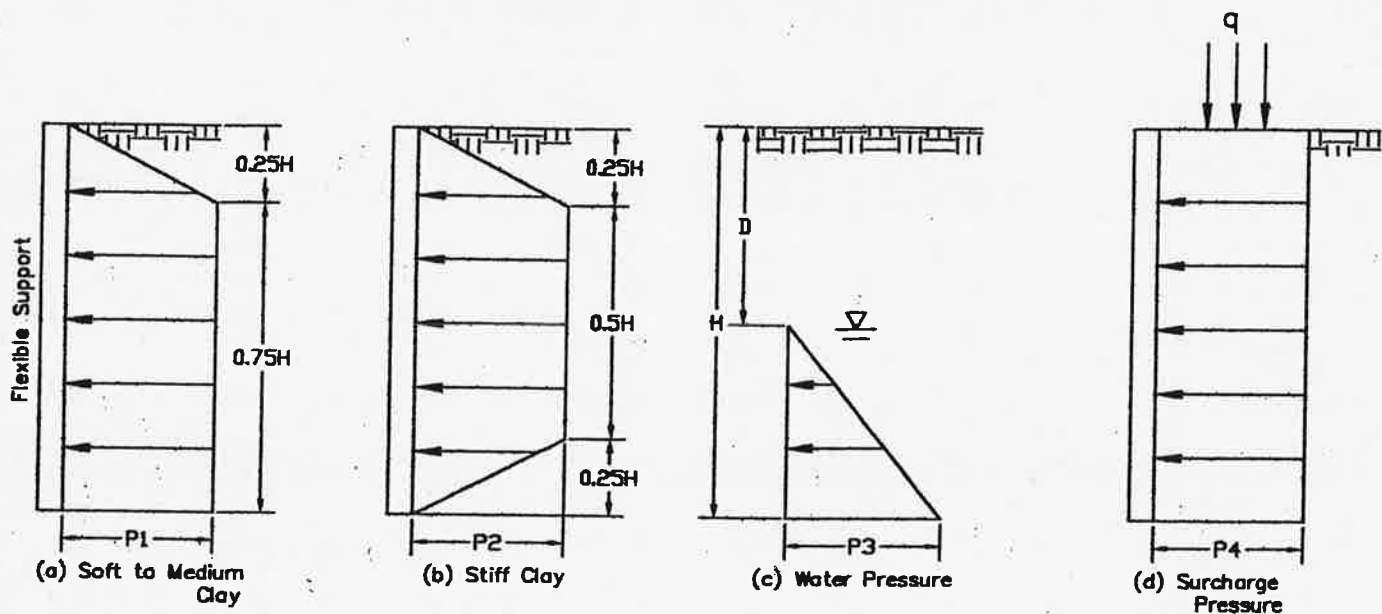
LOGARITHMIC SPIRAL METHOD FOR CALCULATING EARTH PRESSURE AGAINST BRACING



Where,

- O = Center of spiral wedge abd,
- W_t = Weight of wedge abd,
- P_a = Maximum pressure,
- F = Reaction of surface of sliding passing through center O,
- L = Moment arm for P_a ,
- I_w = Moment arm for W_t ,
- δ = Angle between resultant stress on plane and normal to plane,
- ϕ = Angle of internal friction of soil.

**LATERAL PRESSURE DIAGRAMS
FOR OPEN CUTS IN COHESIVE SOIL-LONG TERM CONDITIONS**



Empirical Pressure Distributions

Where:

H = Total excavation depth, feet

D = Depth to water table, feet

$P1$ = Lateral earth pressure = $\gamma H - 4C$, psf

$P2$ = Lateral earth pressure = $0.4\gamma H$, psf

$P3$ = Water pressure = $\gamma_w (H - D)$, psf

$P4$ = Lateral earth pressure caused by surcharge = qK_a , psf

γ = Effective unit weight of soil, pcf

γ_w = Unit weight of water, pcf

C = Drained shear strength or cohesion, psf

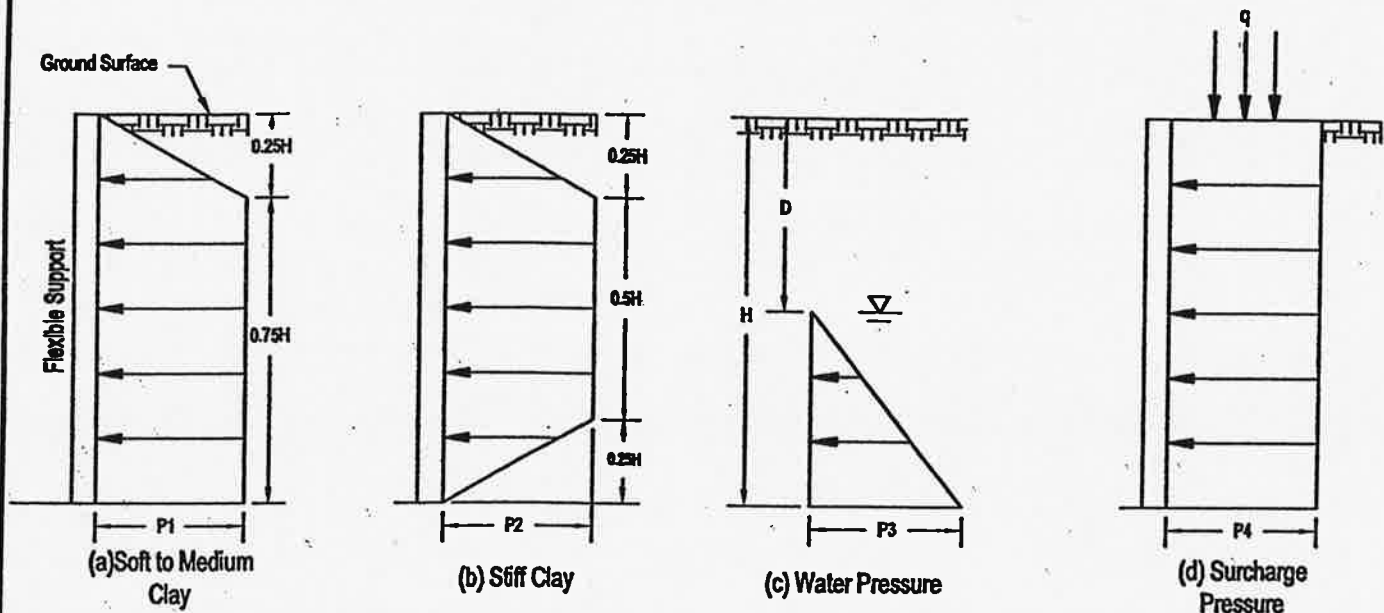
K_a = Coefficient of active earth pressure

Notes:

1. All pressures are additive.
2. No safety factors are included.
3. For use only during long term construction.
4. If $\gamma H/C \geq 4$, use section (b),
If $4 < \gamma H/C < 6$, use larger of section (a) or (b),
If $\gamma H/C > 6$, use section (a).

Reference: Peck, R.B. (1969), "Deep Excavation and Tunneling in soft Ground", 7th ICSMFE, State of art volume, pp. 225-290.

LATERAL PRESSURE DIAGRAMS FOR OPEN CUTS IN COHESIVE SOILS - SHORT TERM CONDITIONS



Empirical Pressure Distributions

where:

H = Total excavation depth, feet

D = Depth to water table, feet

$P1$ = Lateral earth pressure = $\gamma H - 4S_u$, psf

$P2$ = Lateral earth pressure = $0.2\gamma H$, psf

$P3$ = Water pressure = $\gamma_w(H-D)$, psf

$P4$ = Lateral earth pressure caused by surcharge = qK_a , psf

γ = Effective unit weight of soil, pcf

γ_w = Unit weight of water, pcf

S_u = Undrained shear strength = $q_u/2$, psf

q_u = Unconfined compressive strength, psf

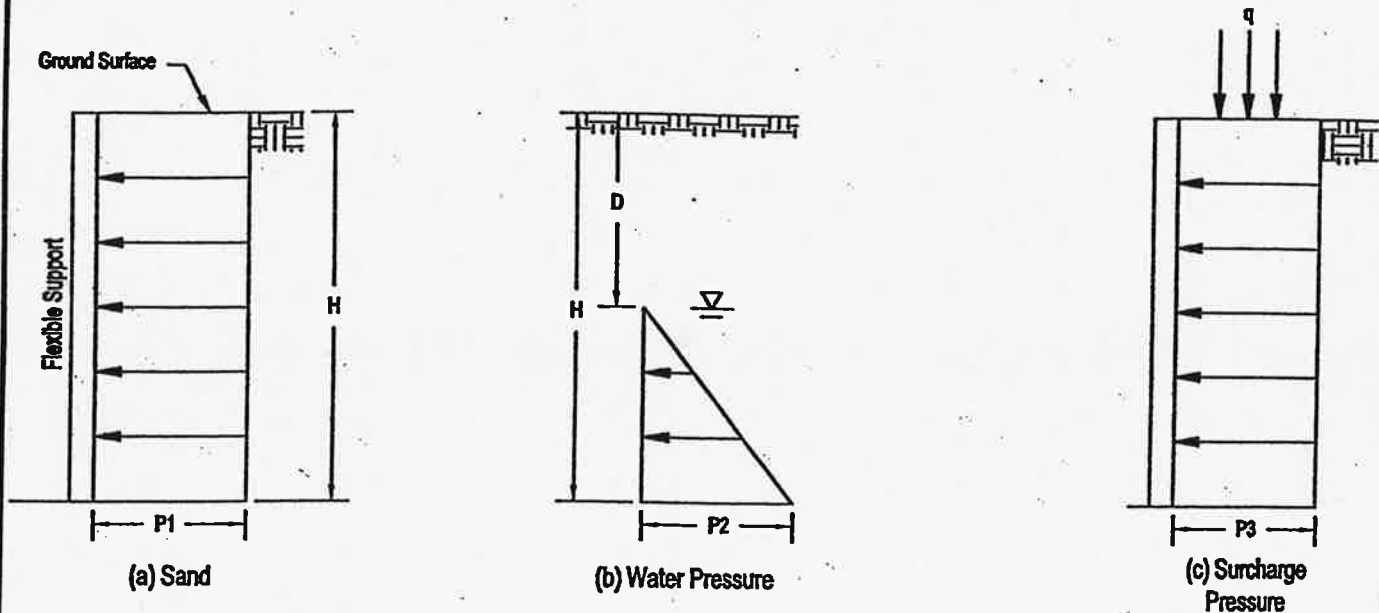
K_a = Coefficient of active earth pressure

Notes:

1. All pressure are additive.
2. No safety factors are included.
3. For use only during short term construction.
4. If $\gamma H/S_u \leq 4$, use section (b),
If $4 < \gamma H/S_u < 6$, use larger of sections (a) or (b),
If $\gamma H/S_u > 4$, use section (a).

Reference: Peck, R.B. (1969), "Deep Excavation and Tunneling in Soft Ground", 7th ICSMFE, State of art volume, pp. 225-290.

LATERAL PRESSURE DIAGRAMS FOR OPEN CUTS IN SAND - LONG TERM CONDITIONS



Empirical Pressure Distributions

where:

H = Total excavation depth, feet

D = Depth to water table, feet

$P1$ = Lateral earth pressure = $0.65 \cdot \gamma H K_a$, psf

$P2$ = Water pressure = $\gamma_w (H - D)$, psf

$P3$ = Lateral earth pressure caused by surcharge = $q K_a$, psf

γ = Effective unit weight of soil, pcf

γ_w = Unit weight of water, pcf

K_a = Coefficient of active earth pressure = $(1 - \sin \phi) / (1 + \sin \phi)$

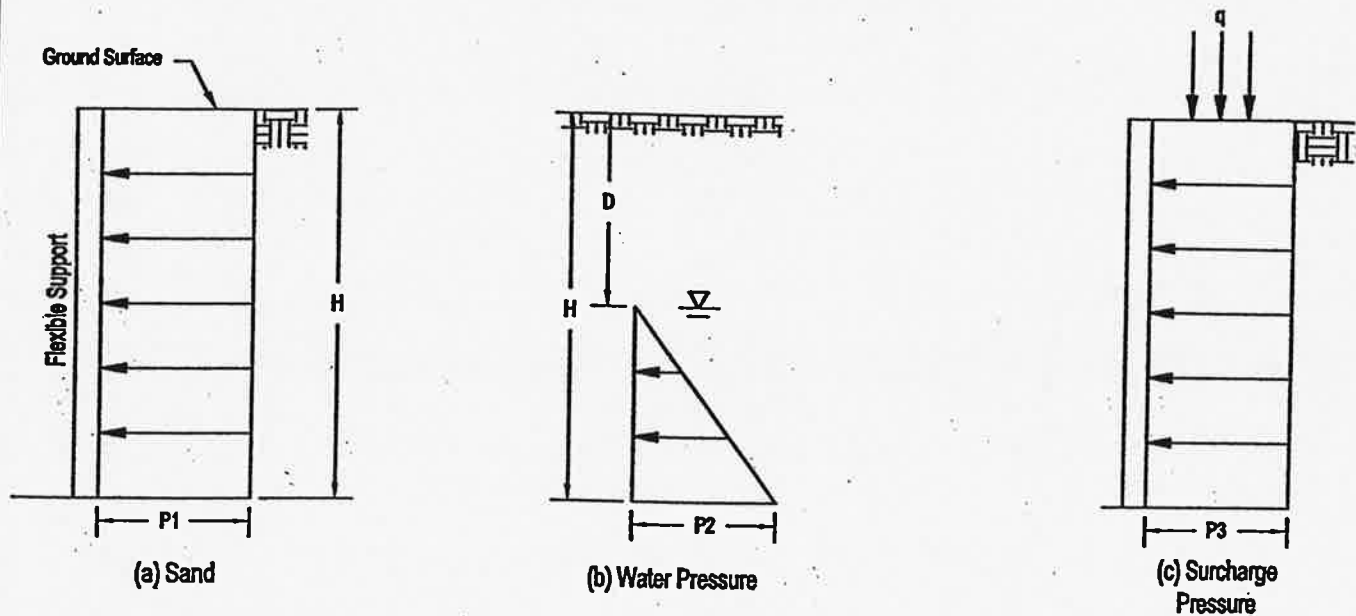
ϕ = Drained friction angle

Notes:

1. All pressure are additive.
2. No safety factors are included.
3. For use only during long term construction.

Reference: Peck, R.B. (1969), "Deep Excavation and Tunneling in Soft Ground", 7th ICSMFE, State of art volume, pp. 225-290.

LATERAL PRESSURE DIAGRAMS FOR OPEN CUTS IN SAND - SHORT TERM CONDITIONS



Empirical Pressure Distributions

where:

H = Total excavation depth, feet

D = Depth to water table, feet

P1 = Lateral earth pressure = $0.65 \cdot \gamma H K_a$, psf

P2 = Water pressure = $\gamma_w (H - D)$, psf

P3 = Lateral earth pressure caused by surcharge = $q K_a$, psf

γ = Effective unit weight of soil, pcf

γ_w = Unit weight of water, pcf

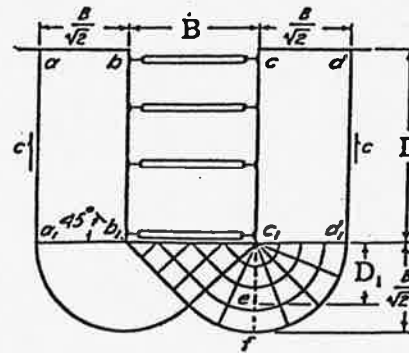
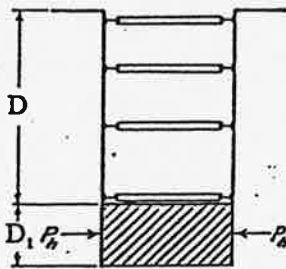
K_a = Coefficient of active earth pressure = $(1 - \sin \phi) / (1 + \sin \phi)$

ϕ = Undrained friction angle

Notes:

1. All pressure are additive.
2. No safety factors are included.
3. For use only during short term construction.

Reference: Peck, R.B. (1969), "Deep Excavation and Tunneling in Soft Ground", 7th ICSMFE, State of art volume, pp. 225-290.



Factor of Safety against bottom heave,

$$F.S. = \frac{N_c \cdot C}{(\gamma \cdot D + P)}$$

where, N_c = Coefficient depending on the dimension of the excavation (see Figure at the bottom),
 C = Undrained shear strength of soil in zone immediately around the bottom of the excavation,
 γ = Unit weight of soil,
 D = Depth of excavation,
 P = Surface surcharge.

If F.S. < 1.5, sheeting should be extended further down to achieve stability.

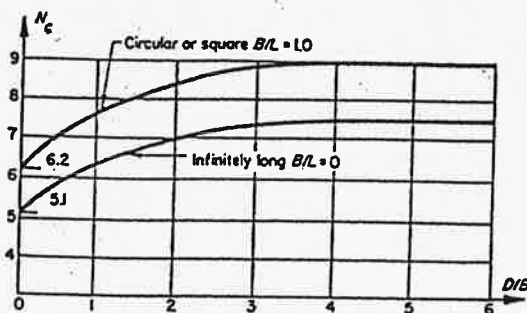
$$\text{Depth of Buried Length, } (D_1) = \frac{1.5(\gamma \cdot D + P) - N_c \cdot C}{(C/B) - 0.5\gamma}; D_1 \geq 5 \text{ ft.}$$

Pressure on buried length, P_h :

$$\text{For } D_1 < 0.47B; P_h = 1.5 D_1 (\gamma \cdot D - 1.4 C \cdot D/B - 3.14C)$$

$$\text{For } D_1 > 0.47B; P_h = 0.7(\gamma \cdot D \cdot B - 1.4 C \cdot D - 3.14C \cdot B)$$

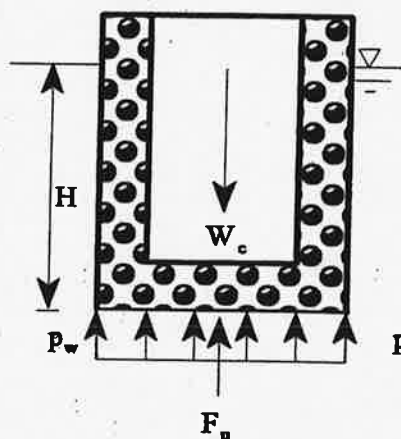
where, B = width of excavation



$$N_{c, \text{rectangular}} = (0.84 + 0.16B/L) N_{c, \text{square}}$$

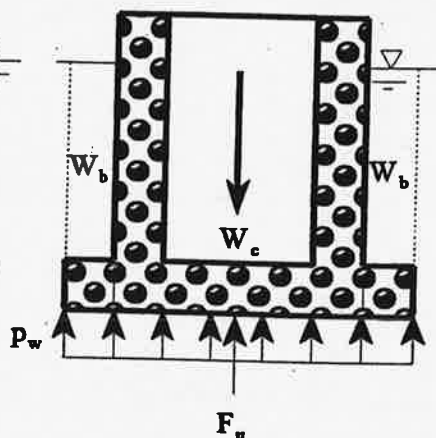
**BOTTOM STABILITY FOR
BRACED EXCAVATION**

(a) Dead Weight of Structure



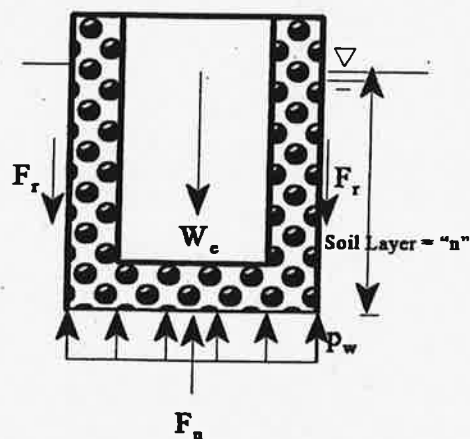
$$\begin{aligned} p_w &= H\gamma_w \\ F_u &= A_b p_w \\ W_c &= S_f F_u \end{aligned}$$

(b) Weight of Backfill Above Base Extension Plus Dead Weight of Structure



$$\begin{aligned} p_w &= H\gamma_w \\ F_u &= A_b p_w \\ W_c + W_b &= S_f F_u \end{aligned}$$

(c) Soil -Wall Friction Plus Dead Weight of Structure



$$\begin{aligned} p_w &= H\gamma_w \\ F_u &= A_b p_w \\ W_c + F_r &= S_f F_u \end{aligned}$$

For Cohesive Soils, $F_r = \alpha c_u A_n$
For Cohesionless Soils, $F_r = p_n K \tan \delta_n A_n$

Where:

- A_b = area of base, sq.ft.
- A_m = cylindrical surface area of layer "n", sq.ft.
- c_m = undrained cohesion of layer "n", psf
- F_u = hydrostatic uplift resistance, lbs
- F_r = friction resistance, lbs
- H = height of buried structure, ft
- K = coefficient of lateral pressure = 0.5
- p_m = average overburden pressure for layer "n", psf
- p_w = hydrostatic uplift pressure, psf
- S_f = factor of safety
- W_b = Weight of backfill above base extension, lbs
- W_c = dead weight of concrete structure, lbs
- α = adhesion factor = 0.5
- δ_n = friction angle between soil layer "n" and concrete wall, degrees = $0.75\phi_n$
- γ_w = unit weight of water = 62.4 pcf

UPLIFT PRESSURE AND RESISTANCE